3 GENERAL MATERIALS AND METHODS

3.1 HOME COMPOSTING TRIAL

3.1.1 Preparation and rationale

The Home Composting Study Area (Section 2.3) was based on 3 refuse collection rounds in the Chertsey, Thorpe and Hythe areas (Figure 2.4). A statistically designed factorial trial was established with the co-operation of 64 homeowners in the Study Area with the following objectives:

- to quantify the potential extent of reductions in domestic waste disposal to landfill by home composting (HC) in RBC;
- to determine the key processes and management factors controlling biodegradation of waste in small compost bins;
- to determine the chemical and microbiological quality of the composted material;
- to quantify the chemical and microbiological quality of the composted material;
- to investigate potential nuisance due to vector attraction;
- to assess the end-use of the material as a soil conditioner and fertiliser product;
- to provide practical guidance to local authorities on the potential waste reductions by, and optimisation of, HC.

3.1.2 Home Composting Study Trial participant recruitment

Sixty four households within the Study Area were approached to participate in the two year research project. The list of households was compiled in April 2000 from respondents to the questionnaire indicating an interest in participating in the research programme (Appendix I). The group of homeowners was initially contacted by telephone to arrange a home interview to explain the objectives of the research and how to undertake the practical work.

3.1.3 Home composting procedure and equipment

Homeowners were supplied with experimental equipment to record the amounts of kitchen, paper and garden waste placed in the compost bins. Participants were requested to segregate non-recyclable paper and card and uncooked kitchen/garden materials from the domestic waste system and compost them in a Milko standard compost bin (Straight Recycling Ltd, Leeds) to balance the moisture content of the waste inputs and maintain aerobic conditions in the bin (Plate 3.1).

Plate 3.1 Inputs of kitchen, paper and garden waste were recorded by homeowners

The Milko standard compost bin has a capacity of 290 l and is fitted with a hinged lid and ventilator. Access to the composted product is provided by a sliding hatch at ground

level. A perforated base and an internal ventilation spike are designed to encourage gas exchange. The Milko compost bin is constructed from recycled plastic materials and has dimensions: 913 mm high x 800 mm diameter base with an aperture diameter of 525 mm (Straight Recycling Ltd, Leeds).

Participants in the trial were supplied with a 10 l kitchen bucket fitted with a hinged lid, a hanging balance and a soil/compost temperature probe with a measuring range of 0-80 °C (Electronic Temperature Instruments Ltd, Worthing). Experimental methods and data recording sheets (see Appendix II) were also provided. Homeowners were asked to measure the following variables:

- weight of kitchen bucket with vegetable and fruit peelings;
- weight of plastic bag with used paper and cardboard;
- depth measurements before and after the addition of garden materials (from top of bin to the surface of compost);
- temperature of compost.

The volume (m^3) of garden waste was calculated as follows:

$$\text{Depth}/100 \times \prod \times r^2$$

Where,
Depth = calculated depth difference (before and after addition of garden waste) in cm
Π = 3.14
r = 0.4 m (radius of compost bin)

3.1.4 Experimental treatments

Homeowners were introduced to the specific experimental treatments as required by the trial design taking account of their ability and willingness to perform these additional functions (see Appendix III, Table A1). Treatments were assigned in factorial combinations by dividing the group into large and small garden size classes. Additional treatments were randomly assigned within each garden size class and included: +/- mixing, +/- proprietary accelerator and +/- earthworm inoculation and +/- mixing. The experimental treatments were replicated four times.

3.1.4.1 Garden size

It is unlikely that there will be a conscious action by homeowners to control the selection of the putrescible organic fraction placed in domestic compost bins to control or optimise the composting process. However, lawn size and the quantity of grass clippings added to the compost bin are principal factors influencing the nature of the feedstock mixture and the potential seasonal differences apparent in the relative proportions of garden and kitchen waste that may impact composting activity and the physico-chemical properties of the composted end-product (Tucker *et al*., 2000). The questionnaire requested details of lawn size and this was used to differentiate between groups with large or small lawns in the home composting trial. The average small lawn size was 37.8 m^2, with a range of 10.7 to 56.7 m^2 and the mean large lawn size was 95.0 m^2 with a range of 57.4 to 177.2 m^2.

3.1.4.2 Mixing

The physical agitation of composting substrates is standard practice for large-scale composting operations to blend feedstock materials, improve homogeneity and pathogen destruction, and to provide aeration and temperature control (Miller *et al*., 1989). This experimental treatment was designed to assess the importance of mixing for aeration and improving the rate of biodegradation and product quality in small domestic composters supplied with frequent inputs of organic waste material. The willingness and

ability of homeowners to perform this function was assessed before the treatment was arranged.

3.1.4.3 Earthworm inoculum

This experimental treatment examined the inoculation of home composters with earthworm species and the potential to accelerate the rate of waste stabilisation. An inoculum of earthworm species (250 g per bin of *Dendrobena* sp and *Eisenia* sp) supplied by a vermiculture specialist (Darryl Poulson, Crimbles Farm, Bury St Edmunds) was introduced to the compost bins assigned this experimental treatment during the period July - September 2000.

3.1.4.4 Proprietary accelerator

A number of proprietary compost accelerators are commercially available, but the quantitative benefits to home composting are uncertain. This experimental treatment examined the effects of a proprietary liquid product (Compost Maker, Biotal, Cardiff), which was replaced with a dry formulation (Garotta, William Sinclair Horticulture Ltd, Lincoln) in the second monitoring year.

3.2 MASS BALANCE ANALYSIS

A mass balance was produced for each compost bin at the end of the first and second year (May 2001 and 2002) of the RBC Home Composting Trial. Materials in each compost bin were collected and weighed in buckets using a hanging scale. Material recovered from the bins was divided into three distinctive layers based on the extent of decomposition (fresh (A), semi-decomposing (B) and composted layers (C)) and the mass of each of these components was measured. Representative composite samples from each layer were collected to determine the moisture content and material from Layer C was subjected to a more extensive suite of chemical analysis (see section 3.4).

3.3 COMPOST PROCESS MONITORING

Temperature and interstitial gas composition measurements of materials undergoing decomposition were obtained to provide information on the biochemical processes operating within the home compost bins.

3.3.1 Temperature

Homeowners were supplied with a soil/compost temperature probe (0-80 ºC) and recorded the temperature of material in the compost bins. This was complemented with more detailed monitoring of temperature conditions using an electronic thermometer fitted with a Type K thermocouple sensor mounted in a penetration probe (1 m long and 10 mm diameter) (Hanna Instruments, Leighton Buzzard). Temperature profiles were constructed by inserting the probe at increasing depths of 10 cm from the compost surface in a fixed pattern of four equidistant quadrants located in the north, south, east and west positions of the bins using a compass.

Temperature profiles were measured of all the compost bins on 6 occasions during the Home Composting Trial and the dates of specific monitoring activities are listed in Table 3.1.

3.3.2 Gas composition

Oxygen, CO_2 and CH_4 concentrations in the interstitial gas within the organic material was measured using a GA2000 Gas Analyser (Geotechnical Instruments Ltd, Leamington Spa). The gas sampling probe was inserted at increasing depths of 10 cm from the compost surface in the four quadrants of the bin adopting the same procedure used for measuring compost temperature. Gas monitoring was performed on all the compost bins on 5 occasions during the experimental period and the dates of these home visits are presented in Table 3.1.

Table 3.1 Monitoring activities

Date of home visits	Monitoring parameter	
	Temperature	Gas
July 2000	No	Yes
December 2000	Yes	Yes
March 2001	Yes	Yes
September 2001	Yes	Yes
December 2001	Yes	Yes
March 2002	Yes	Yes

3.4 LABORATORY ANALYTICAL PROCEDURES

Samples of composted material from each layer (A,B and C, see Section 3.2) collected each year during the dismantling of the compost bins were analysed for a suite of chemical determinands using standard laboratory techniques (MAFF, 1986; SCA, 1986a,b). Compost samples were collected from the bins for analysis during May 2001 at the end of the first year and during April 2001 after the second year.

Throughout all the analytical work, deionised water (Purite RO 100) was used and reagents were of analytical quality grade. Glassware was acid washed in 10 % nitric acid.

Samples were thoroughly mixed in order to achieve homogeneity. Chemical analyses requiring dry compost samples were performed with material that was dried in a forced-air oven set at 80° C for 48 h and ground using a pestle and mortar to pass a 2 mm sieve, to minimise sub-sample variability. Individual replicate data from the chemical analyses of layer C are presented in Appendix V.

3.4.1 Oven-Dry moisture content

Compost from all sampling layers were examined for moisture content. Samples of fresh compost were weighed and placed in a forced-air oven at 105 ºC for 24 hours. Oven dried samples were cooled in a dessicator for 1 h and reweighed. The percentage moisture content was calculated from the equation (MAFF, 1986):

$$\text{Moisture content (\%)} = \frac{(\text{wet mass} - \text{dry mass}) \times 100}{\text{Wet mass}}$$

3.4.2 pH

The pH of compost samples was determined using standard procedures (Method 32; MAFF, 1986). A sub-sample (5 g) of air-dried ground compost was transferred into a bottle and 25 ml of water was added. The bottles were capped and shaken mechanically at 200 revs per min for 15 min. The pH of the suspension was measured using an electronic pH meter 420A (Aston).

3.4.3 Electrical Conductivity (EC)

The Electrical Conductivity was determined following a standard procedure (Method 24; MAFF, 1986). A sub-sample of 20 g of air-dried and ground compost was transferred to a 125 ml bottle and 50 ml of saturated calcium sulphate solution (20°C) was added. The

bottles were capped and shaken at 20°C (the laboratory environment was air-conditioned and maintained at a constant temperature of 20°C). The samples were filtered through 125 mm Whatman No. 2 filter papers into 60 ml bottles and the filtrates were retained for the determination of the conductivity using a conductivity meter (ExTech, Barnes).

3.4.4 Loss on ignition/organic C

The organic matter content of composts, sludges and manures is routinely measured from the volatile solids loss on ignition (LOI).

Compost samples were dried at 105 ºC, weighed and thermally ignited at 375 °C in a muffle furnace for 16 h and the induced ash was re-weighed (MAFF; 1986). The volatile solids content was expressed as a percentage (m/m) and calculated using the formula:

$$\text{Volatile solids (\%)} = \frac{(\text{mass of dry sample} - \text{mass of ash}) \times 100}{\text{mass of dry sample}}$$

3.4.5 Extractable NH_4-N, NO_2-N and NO_3-N

A standard extraction procedure was followed for the determination of NH_4-N, NO_2-N and NO_3-N concentrations in compost samples from layer C (Method 53; MAFF, 1986). Sub-samples of fresh compost (20 g) were transferred to 350 ml bottles and 100 ml of 2 M potassium chloride solution were added. The bottles were capped and shaken for 2 h on a laboratory shaker at a rate of 200 revs per min. The suspensions were filtered through 150 mm Whatman No. 40 filter papers and concentrations of NH_4-N, NO_2-N and NO_3-N in the filtrates were measured using a Skalar San plus autoanalysis system (Breda, The Netherlands).

3.4.6 Total N and P

Total N and P were determined by standard procedures (SCA, 1986a). Fresh sub-samples (1 g) of compost were placed in digestion tubes and 2 potassium chloride tablets and anti-bumping granules were added. Sulphuric acid (40ml) was carefully added to the digestion tubes and the tubes were heated to 180 °C in a heating block for 2 h (Gerhardt, Bonn, Germany). On completion of digestion, 30-40 ml of water were added slowly after cooling. The diluted acid mixture was made up to 250 ml in a volumetric flask and total concentrations of N and P were measured using a Skalar San plus autoanalyser (Breda, The Netherlands).

3.4.7 Extractable P

The extractable P concentration in compost and field plot soil samples (see Section 9) was measured following Method 59 in MAFF (1986). Air-dried ground samples (5g) were transferred into extraction bottles and 100 ml of sodium bicarbonate reagent at pH 8.5 was added. The bottles were capped and shaken on the laboratory shaker for 30 min at 200 revs per min. The suspensions were filtered through a 125 mm Whatman No. 2 filter papers and determined for extractable P using a Skalar San plus autoanalysis system (Breda, The Netherlands).

3.4.8 Total Mg and K

Total Mg and K concentrations were determined by a standard hydrochloric- nitric acid digestion procedure (Method E; SCA, 1986b). Oven-dried and ground compost, plant material and soil samples from field plots (1g) were transferred to digestion vessel of 100 ml volume fitted with a small air condenser. Samples were moistened by adding 5 +/- 0.5 ml of water to each tube. Hydrochloric acid (d_{20} 1.18) of volume 12 ml +/- 0.2 ml and 4 ml +/- 0.1 ml of nitric acid (d_{20} 1.42) were added down the side of the tubes. The tubes were placed in a rack and any vigorous initial reaction was left to subside. In addition, 1 +/- 0.05 ml n-dodecane and a few anti-bumping granules were added to the tubes. The tubes were placed on a heating mantle and the heating control was adjusted until the sample gently refluxed at 60 °C. The digestion took place under gentle reflux for 2 h. After cooling, 1 +/- ml of 50,000 mg l^{-1} caesium solution was added and the digestates were diluted to 50 ml with distilled water and thoroughly mixed. The solution was filtered through an acid resistant (hardened ashless) cellulose filter paper (Whatman No. 42) into a polypropylene bottle.

Determination of the metals was carried out by atomic absorption spectrophotometery (AAS) (Perkin-Elmer 5100 PC with a 90 AS (auto sample) and AA Win Lab Software).

For each batch of samples processed, a method blank was carried throughout the sample preparation and analytical process and was used for background correction. The metal concentrations were corrected in relation to the blank concentration (Table 3.2). Both the digestion and the analysis by atomic absorption were randomised. Some randomly chosen samples were duplicated and were spiked to assess the recovery and accuracy of the analytical procedures. Stock solutions containing 1000 mg $l^{-1}$of each ion were prepared using K and Mg salts. The spike solution was prepared In a 500 ml volumetric flask by adding 100 ml of the K stock, 25 ml of the Mg stock and 50 ml of concentrated nitric acid made up to volume with 10 % nitric acid. The spike solution (10 ml) was added to the samples/blanks selected as part of the quality assurance procedure. Spiked blanks were also carried out in each batch of samples examined.

Table 3.2 Blank correction

Metal	Blank concentration (mg l^{-1})
Mg	0.02
K	0.05

The extraction efficiency of spiked blanks was within an acceptable range: +/- 5 % for both elements. The recovery efficiency of spiked samples was in the range 84 % (Mg) to 94 % (K) and indicated that the AAS analysis, the extraction method, and transferring and filtering procedures operated correctly.

3.5 STATISTICAL ANALYSIS

Statistical analysis of experimental results were performed using the GENSTAT 5 for WINDOWS statistical software package (IACR-Rothamsted Experimental Station, 1997). The statistical significance of the experimental treatments was determined by analysis of variance and differences between means were compared using the Least Significant Difference at $P = 0.05$.

Linear regression analysis was applied to data summarising the relationships between nutritional status of home composts, peat and soil samples and flower production responses of petunias in the field trial (Section 9).