The GROWS Project

(Green Recycling of Organic Waste from Supermarkets)

Part 2: Agricultural Field Trials Phase Using GROWS Compost

Final Report

BIFFAWARD Project Number B/989/1150b
ENTRUST Project Number 710247.004

Report produced by

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The GROWS Project
(Green Recycling of Organic Waste from Supermarkets)
Part 2: Agricultural Field Trials Phase Using GROWS Compost
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Executive summary

The objective of the GROWS (Green Recycling of Organic Waste from Supermarkets) project was:

"*To establish a cost effective, sustainable and environmentally sound waste management solution for biodegradable waste from supermarkets*".

Funding for the GROWS project was secured by the Progressive Farming Trust Ltd through Biffaward, a multi-million pound environment fund which uses landfill tax credits donated by Biffa Waste Services. Third party funding was provided by Waitrose, Sainsbury's and Sheepdrove Organic Farm. Project management and implementation was undertaken by the Organic Resource Agency Ltd.

The first part of the GROWS project involved setting up a system for source-separating supermarket fruit, vegetable and cut-flower waste in-store, developing a collection round to service the participating stores and composting the waste once it had been delivered to the GROWS composting site at Sheepdrove Organic Farm in Berkshire. During this collection and composting phase an intensive year-long audit of the waste was carried out to assess the quantity and quality of fruit and vegetable waste that could be collected. A complimentary programme of monitoring was also undertaken to assess three different composting systems (open windrow, covered Gore® system, and BioSal in-vessel) to see how each system coped with the GROWS waste stream. Results from this part of the project were published in a separate document – GROWS Project Part 1: Collection and Composting Phase (Pickering and Bulson, 2002).

The field trials phase of the GROWS project followed on from the composting phase, beginning in autumn 2001, and running through the growing season of 2001-2002 until harvest at the end of August 2002. Using composts produced in phase one of the project, the objectives for the field trials phase were to:

- investigate if compost made from GROWS waste had any impact (positive or negative) on crop growth and soil fertility in an arable rotation.
- investigate if different test crops responded differently to compost application.
- investigate if there was any crop response or difference in soil fertility to compost applications from the different *types* of compost (three different systems).
- To investigate if there was a crop response or difference in soil fertility due to the different *rates* of compost applied.
- To assess the economic value of the compost to the farmer.

Summary of results

Crop growth

- Increasing the *rate* of compost application led to an increase in grain yield from the triticale trial. This increase in yield relative to the control was found to be statistically significant ($p<0.01$) at the highest level of compost application. However, there was no significant impact on crop yield due to the different *types* of compost used in the trial.

- The compost treatments did not have any significant effect on crop emergence.

Economic benefits of compost application

- Economic benefit of the compost treatments was assessed by calculating the financial gross margin produced from the sale of the triticale grain yield under each of the compost treatments. Once the cost of applying the compost was taken into account, the financial benefit of £9.00/ha was very small at the two lowest rates of application. However, at the highest rate of application the increase in gross margin of £39/ha was considerable. It should be noted that the value of the compost, when calculated in this way is dependant on the yield and value of the crop being grown. For a more accurate analysis of value, calculations should be made over a whole crop rotation, although this would mean carrying out trials over an extended period of several years.

Gross margin associated with the sale of organic triticale grain for animal feed, allowing for the different compost application rates used in the GROWS field trial.

	Control **0 N/ha/yr**	**170 N/ha/yr**	**250 N/ha/yr**	**500kg N/ha/yr**
Output[1]				
Grain yield (t/ha)	3.56	3.95	3.95	4.47
Grain Value (£/t)	165.00	165.00	165.00	165.00
Crop Value (£/ha)	**587.40**	**651.75**	**651.75**	**737.55**
Inputs				
Seed Costs (£/ha) (250kg/ha @ £490/tonne)	**122.5**	**122.5**	**122.5**	**122.5**
Compost applied (fresh tonnes/ha)	0.00	27.70	40.70	81.40
Cost of compost application (£/ha)[2]	**0.00**	**55.50**	**55.50**	**111.00**
Gross Margin (£/ha) (Output – Inputs)	**464.90**	**473.75**	**473.75**	**504.05**

[1] Outputs are calculated without inclusion of any government subsidies

[2] Application of bulky organic matter is not an exact science, and calculating exact costs/tonne applied is difficult as the farmer rarely knows precisely how much is applied – instead costings are usually calculated in £/hr. However, using the machinery at Sheepdrove Organic Farm it was calculated that an application rate of 37 tonnes/ha of bulky organic matter could be costed at £55.50/ha. It was estimated that the two lowest compost application rates used in the trial would take approximately the same time and man-power, but that the highest rate would take double the time to achieve, hence the entries given in the table.

Assessment of compost characteristics

- When compared on a dry weight basis, the three types of compost used in the trial (Open windrow, covered Gore® system and BioSal in-vessel system) differed only slightly. The BioSal compost appeared to have a slightly higher phosphorus and potassium content which was attributed to the fact that it had not been stored as long as the other two types of compost before use and may therefore have been exposed to less leaching by the rain.
- All the GROWS composts contained more nitrogen than green waste compost and more phosphorus and potassium than both green waste compost and cattle manure from organic farms, when compared on a dry weight basis.

Impacts on the soil

- Application of the composts to the field plots resulted in a positive response in terms of available phosphorus, potassium, magnesium and organic matter. Increasing rates of compost led to significant increases in the levels of the above parameters immediately after compost application and elevated levels of available phosphorus and potassium were still detectable at harvest one year later.

Weed growth

- The use of the GROWS composts did not introduce exotic weeds into the organic farming system. It appeared that although viable seeds were present in the raw waste (from the fruit and vegetable matter), these did not survive the composting and maturation process prior to being applied to the land.
- Application of the composts did not stimulate existing weeds by supplying supplementary nutrition, or more favourable soil conditions for improved germination.

Pests and disease

- No pests or disease were observed in the triticale trial.
- Although pest and disease was observed in the winter bean trial, there was no indication that these were linked to any of the applied compost treatments.

Overall conclusions

Compost manufactured from supermarket waste was found to be relatively low in contaminants and contained favourable levels of major nutrients when compared with other common bulky organic soil amendments, regardless of the type of composting system used. GROWS compost did not lead to the introduction of exotic weeds or the direct incidence of major pests or disease. Yields were increased through application of the compost in the case of triticale, although only at the highest rate was this yield increase statistically significant. Similarly, only at the highest compost application was the financial benefit useful, and this has to be balanced against the fact that in many situations high application rates of compost (500kg nitrogen /hectare/year) will not be possible due to regulatory restrictions (e.g. organic production legislation and the restrictions due to Nitrate Vulnerable Zones -NVZs). Lower rate applications of compost, within the 170kg N /ha/year limit are unlikely to be cost effective based solely on short term gross margin calculations. Over the longer term, this work supports the findings of others who conclude that repeated compost applications are likely to be beneficial through the gradual improvement of soil fertility. However, trials spanning a whole crop rotation or longer would be needed to assess this.

In the opinion of the authors, the findings of this report support the view that the economic value of GROWS compost, applied in accordance with existing regulations as a general agricultural soil conditioner, is insufficient to allow any additional revenue generated directly from utilising the compost to be offset against the cost of the compost's production. Its utilisation for alternative, higher value end uses may change this position, although in these situations there is likely to be a concurrent increase in processing costs to obtain the higher specification end-product required. When compared against landfilling, the GROWS model remains more expensive and this will not change unless:

a) Collection and landfill charges of mixed waste increase to a point which are closer to the costs of the GROWS model.
b) Collection costs of source separated supermarket waste can be reduced, perhaps by combining waste collections from different sectors.
c) Grain prices increase significantly, thereby providing more of an incentive for farmers to make and apply compost to land to raise yields.
d) Other legislative drivers or subsidies make source separation/composting more attractive than landfilling of mixed waste, e.g. a subsidy based on soil carbon content becoming available within the context of any proposed EU soils strategy.

Acknowledgements

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1.0 Introduction

The objective of the GROWS (Green Recycling of Organic Waste from Supermarkets) project was:

"*To establish a cost effective, sustainable and environmentally sound waste management solution for biodegradable waste from supermarkets*".

The innovative concept behind GROWS was that supermarket food which could not be sold or given to charity, could be used to produce more food rather than being wasted. In GROWS this would be achieved by on-farm composting of fruit, vegetable and cut-flower waste from supermarkets. The compost would be used to help maintain soil fertility on an organic farm, which in turn would benefit crop growth. GROWS would therefore offer food retailers an environmentally-sound means of managing unsold produce. At the same time this would also provide the farmer with both an alternative source of income, through gate-fees for accepting the material into their composting facility, and a potentially useful soil improver for use on their land. GROWS represents a complete cycle of food production, by closing the loop between the producer and the retailer (Plate 1).

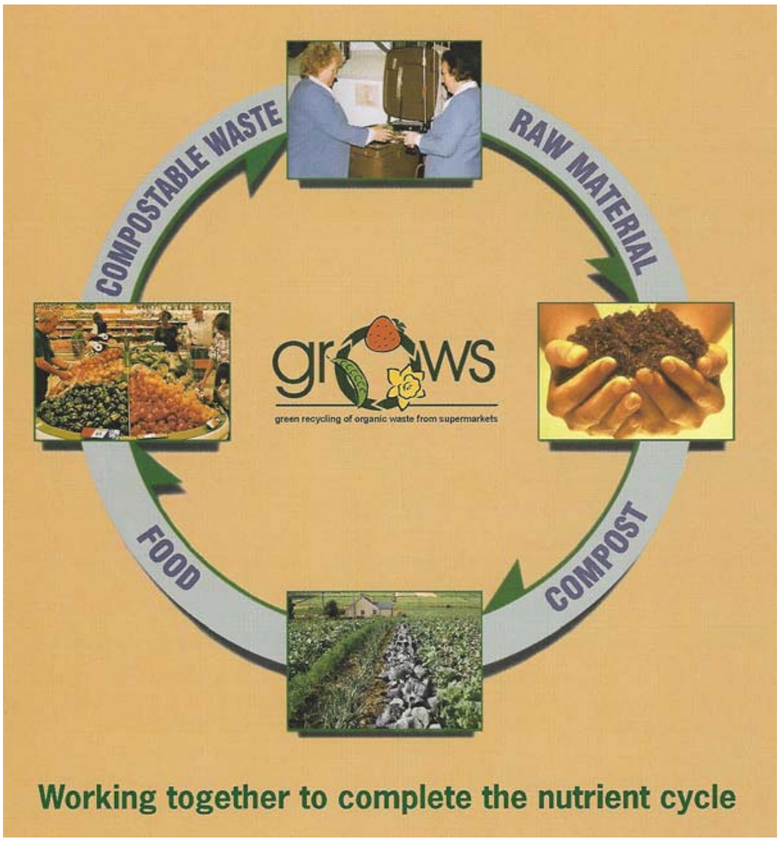


Plate 1. Illustration of GROWS concept

All participants in the cycle needed to be involved to bring the concept behind GROWS to life. In a unique collaboration, the GROWS partnership brought together the food retailers Waitrose and Sainsbury's, as third party funding bodies, and generators of organic waste. They joined forces with Sheepdrove Organic Farm near Lambourn in West Berkshire, which also provided third party funding, and hosted the composting operation and field trials. Main funding was secured by the Progressive Farming Trust Ltd. through Biffaward, a multi-million pound environment fund, which utilises landfill tax credits donated by Biffa Waste Services. The Organic Resource Agency Ltd. managed the project and carried out the composting and research operations.

The field trials phase of the GROWS project depended on a separate funding application to Biffaward, and confirmation of this funding was only received towards the end of the composting phase. For this reason field trials were scheduled to follow on from the composting phase, beginning in autumn 2001, and running through the growing season of 2001-2002 until harvest at the end of August 2002.

This final report describes the rationale behind the field trials, details their set-up and the monitoring regime used, and presents and discusses the results obtained, with the aim of assessing the agronomic and economic value of compost produced from supermarket fruit, vegetable and cut flower waste.

Several specific objectives were set for this piece of work utilising the GROWS composts:

- To investigate if compost made from GROWS waste had any impact (positive or negative) on crop growth and soil fertility in an arable rotation.
- To investigate if different test crops responded differently to compost application.
- To investigate if there was any crop response or difference in soil fertility to compost applications from the different *types* of compost (three different systems).
- To investigate if there was a crop response or difference in soil fertility due to the different *rates* of compost applied.
- To assess the economic value of the compost to the farmer.

2.0 Method

The GROWS field trials were conducted at Sheepdrove Organic Farm in an organic arable field used for winter wheat the previous season. The site sloped gently to the south east (Plate 2). The soil was flinty clay over chalk and had been prepared prior to sowing by shallow ploughing in the late summer of 2001. Although stony, there was little other debris or visible weed growth on the site prior to sowing.

Two crops were chosen as test species for the field trials: triticale and winter field beans. Triticale is a hybrid between rye and durum wheat. It is grown for its grain which is used predominantly as animal feed. It is generally disease-resistant and out-yields wheat on poorer soils, but because it produces long straw it can suffer from 'lodging' (damage caused when the wind blows the stems over). It is managed the same way as winter wheat. It is a good test crop because it is drought resistant and grows well on the chalky soils found at Sheepdrove and responds well to nitrogen making it a useful indicator of soil fertility levels. Winter field beans are also grown for animal feed. As a legume crop (which can fix nitrogen from the atmosphere) it is less responsive to nitrogen in the soil but will respond to additional potassium, making it another useful test crop. In addition winter beans are susceptible to drought, so it is possible to obtain a yield response to increased moisture retention due to compost application with this crop.

Prior to sowing, the field plots received compost from the three composting systems studied in the first phase of the project (open windrow, Gore® and BioSal in-vessel) applied at three rates. Application rates were based on total nitrogen content and adjusted for differing bulk density, moisture and nitrogen content in each of the three composts. The nitrogen application rates chosen were 170 kg, 250 kg and 500 kg of total nitrogen per hectare. The 170 kg N/ha corresponds to the maximum total nitrogen application rate to land permitted per year under EC regulations for organic production (EEC, 1999) and will also correspond to the maximum total nitrogen application in manure allowed once the government's Nitrate Vulnerable Zone (NVZ) Action Programme has been in force for its initial 4 year start-up period (DEFRA 2002). The 250 kg/ha/year rate is the maximum total nitrogen application rate per year laid down in the Code of Good Agricultural Practice for the Protection of Water (MAFF, 1991). The 500 kg/ha rate was chosen to investigate what effect doubling the maximum recommended rate would have on crop growth. This double rate is permitted under the MAFF Code of Good Agricultural Practice for certain composted wastes if applications are restricted to once every two years. A control treatment and replication enabled statistical analysis and interpretation of results.

The site was marked out in September 2001 (Plate 3). There were two independent trials, one for each crop. Within each trial there were thirty plots split into three replicated blocks of ten plots each. Each treatment (Table 1) was represented once in each block and each plot measured 4 m x 10 m. There was one control plot in each block to which no compost was applied. The replication was included to allow statistical analysis of the data as an incomplete factorial experiment.

Compost was applied to the plots on 16th October 2001 in pre-measured volumes to ensure accurate application rates, and raked across each plot to ensure even distribution. Chemical analysis of each batch of compost prior to compost application ensured accurate nitrogen application as well as supplying supporting information about the composition of the composts. Details of the pre-application analyses are provided in Table 2.

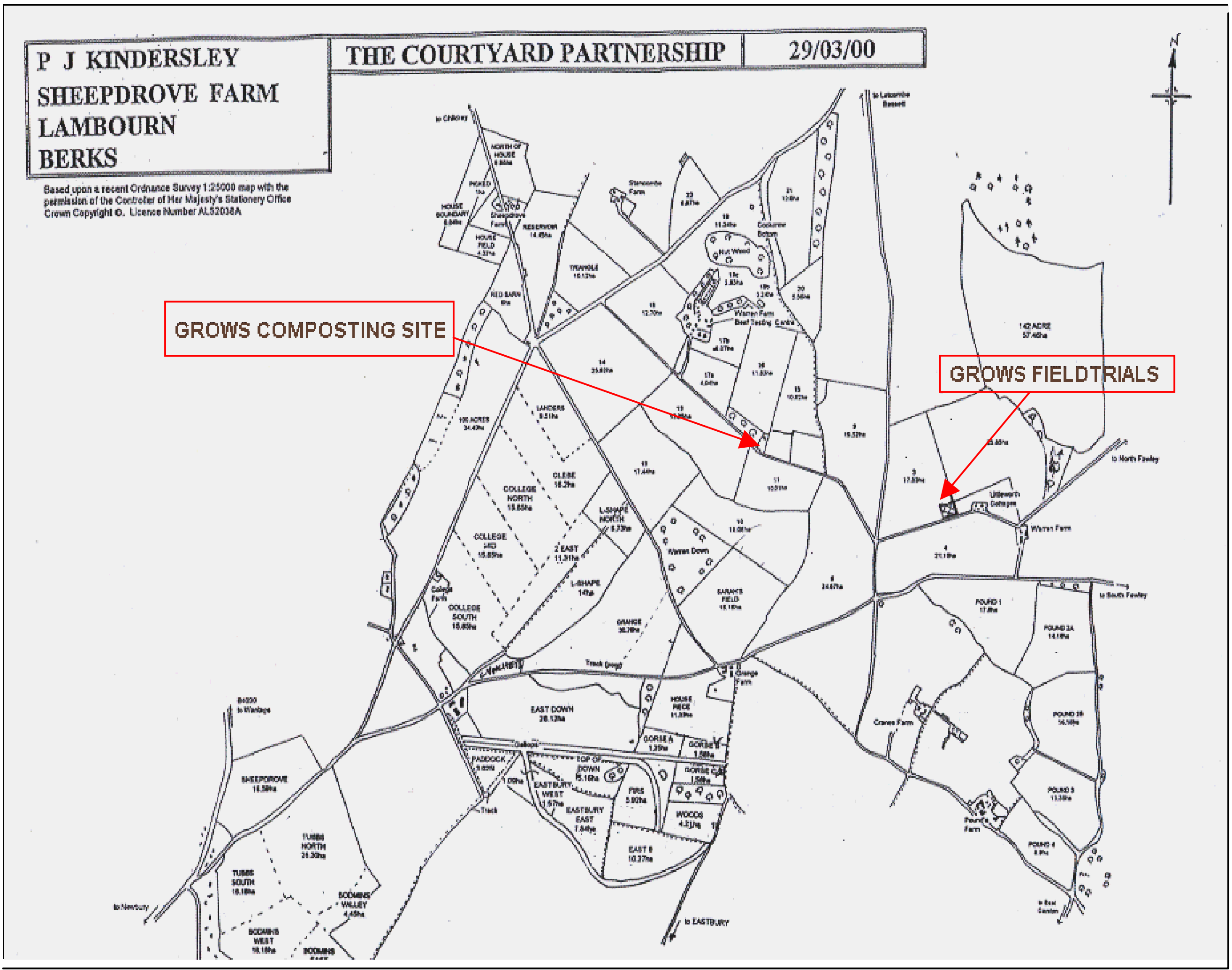


Plate 2. Map of Sheepdrove Organic Farm showing location of the GROWS composting site and position of the GROWS field trials on the farm

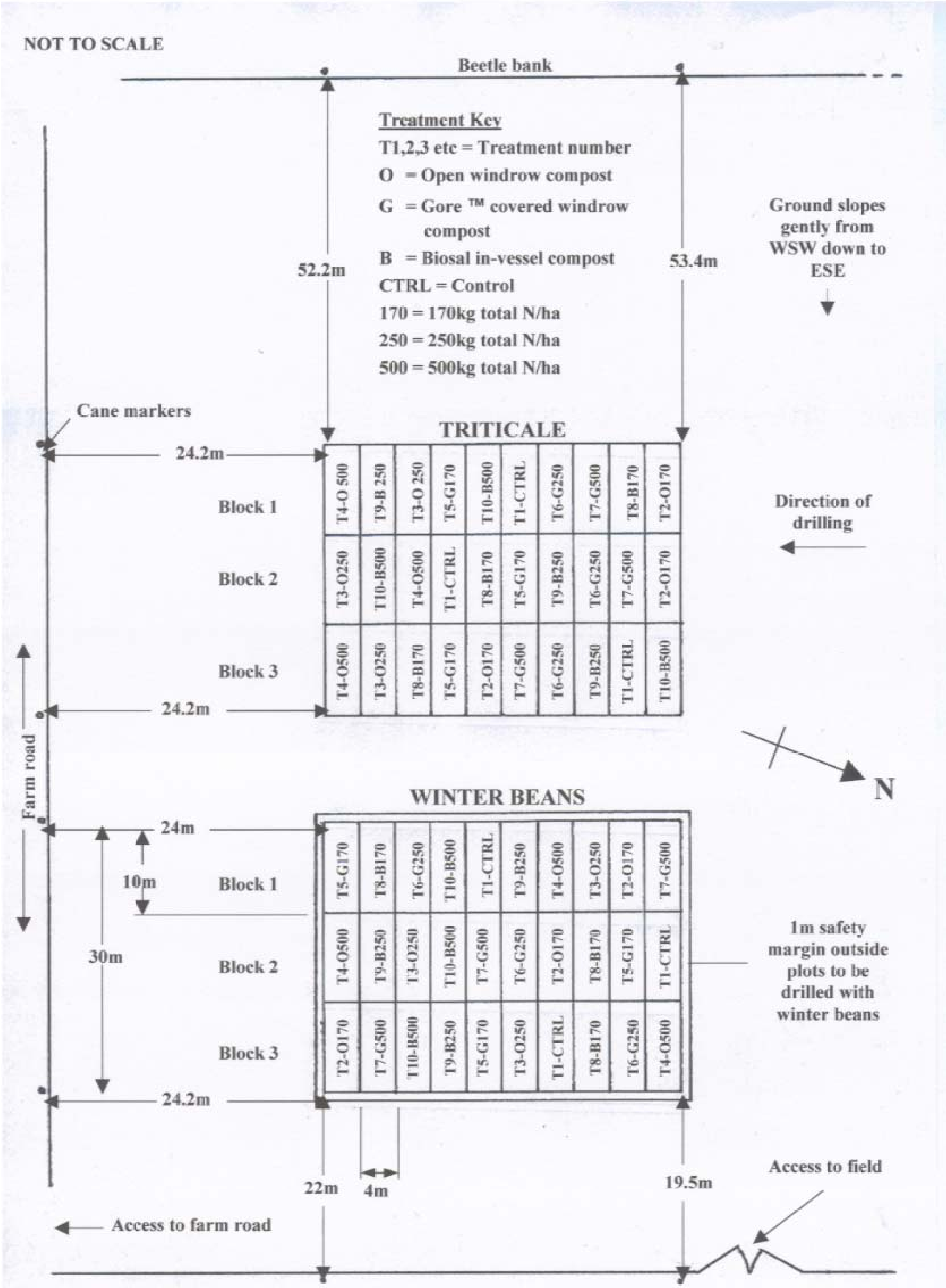


Plate 3. Plan of GROWS field trials showing layout of trials area in relation to field boundaries and treatment structure (not to scale).

Treatment No.	Treatment Code	Treatment Description
1	CTRL	Control
2	O170	Open windrow compost – 170 kg total N/ha
3	O250	Open windrow compost – 250 kg total N/ha
4	O500	Open windrow compost – 500 kg total N/ha
5	G170	Gore® system compost – 170 kg total N/ha
6	G250	Gore® system compost – 250 kg total N/ha
7	G500	Gore® system compost – 500 kg total N/ha
8	B170	BioSal in-vessel compost – 170 kg total N/ha
9	B250	BioSal in-vessel compost – 250 kg total N/ha
10	B500	BioSal in-vessel compost – 500 kg total N/ha

Table 1. List of treatments and treatment codes used in the field trials (repeated for each crop)

Analysis	Open Windrow	Gore® System	BioSal In-Vessel
Dry Matter (%)	34.5	32.5	31.0
Total Nitrogen (%w/w)	1.78	1.96	1.91
Total Carbon (%w/w)	40.6	30.9	34.5
C:N Ratio	23:1	16:1	18:1
Total Phosphorus (%w/w)	0.88	0.77	1.04
Total Potassium (%w/w)	2.71	2.73	3.01
Total Magnesium (%w/w)	0.50	0.59	0.37
Total Calcium (%w/w)	4.96	4.15	3.29
Total Iron (%w/w)	1.70	0.36	0.35
Nitrate Nitrogen (mg/kg)	696	895	89
Ammonium Nitrogen (mg/kg)	243	218	1503
Electrical Conductivity (mmhos)	2.30	1.35	1.08
pH (1:6 water)	8.68	9.19	9.45
Total Copper (mg/kg)	**1046**	83.3	86.8
Total Zinc (mg/kg)	203	172	264
Total Lead (mg/kg)	8.13	17.6	4.85
Total Cadmium (mg/kg)	0.39	0.28	0.55
Total Mercury (mg/kg)	<0.05	<0.05	<0.05
Total Nickel (mg/kg)	9.03	5.36	4.46
Total Chromium (mg/kg)	9.68	4.56	7.77

Table 2. Nutrient and metal analyses of different compost types to be applied to field trials.

Drilling was done using an 'Accord Ferag' pneumatic power harrow drill which both drilled the seed and partially cultivated the soil surface incorporating the compost. The triticale trial was drilled on 30th October 2001 using a variety of triticale called 'Ego' applied at a rate of 247.1 kg/ha (100 kg/acre). The field beans were drilled at the same rate on 8th November 2001 using a variety called 'Clipper'. 'Hum-line' (thin nylon twine that vibrates and makes a noise in the wind) and bird scaring balloons were erected around the plots in an attempt to minimise bird damage which was known to be particularly problematic on bean crops.

Monitoring was then undertaken over the subsequent growing season to try to establish if the type or amount of compost applied to the two crops significantly affected the following range of parameters:

- Soil nutrient and heavy metal levels just after sowing
- Crop establishment
- Weed growth during crop establishment
- Nutrient concentrations in the plant tissues of each growing crop
- Incidence of pests and/or disease
- Yield and crop quality
- Residual soil nutrient and heavy metal levels directly following harvest.

Soil samples were taken on 29th November from the triticale trial and on the 10th December from the winter beans. Ten soil cores from the 0-15cm soil layer in each plot were taken and bulked together before being analysed for the following nutrients and metals:

- pH
- Available phosphorus
- Available potassium
- Available magnesium
- Organic matter
- Total copper
- Total zinc
- Total lead
- Total cadmium
- Total mercury
- Total nickel
- Total chromium

Establishment monitoring was carried out on 4th January 2002 to assess how well the seedlings were germinating and emerging. This involved randomly selecting four rows in each plot and counting the number of seedlings that had emerged along a one metre drill row. The average per metre for each plot was then calculated, and, knowing the coulter width on the drill (9 cm), a value for the number of emerged seedlings/m^2 was calculated.

Weed assessments were conducted on two separate occasions in the spring (3rd April 2002 and 21st May 2002) and comprised measurements of weed population density at the species level. Weeds were assessed using three randomly placed quadrats per plot, avoiding the plot edges. Two sizes of quadrat were used; on the 03-April-2002 a 0.0625 m^2 quadrat was used, whilst on the 21-May-2002 the quadrat size was 0.25 m^2.

Samples of plant tissue were taken from each plot on 21st May 2002 and tested for a range of major nutrients and trace elements. In the triticale trial, 10 random plants were selected in each plot and cut off at ground level for tissue analysis. In the winter bean trial 20 plants were randomly selected in each plot and the young, newly opened leaves were removed and sent off for analysis.

A qualitative assessment of disease incidence in each trial was made on 17th July 2002. Five randomly selected plants on each plot (in each trial) were monitored for common pests, diseases and disorders. Where present, each disease/pest/disorder was assessed and a score of between 1-5 awarded to each plot, where 1 represented a total absence of disease and 5 represented total infestation of the plants with the specific disease/pest/disorder symptoms.

Both crops were harvested on 29th August 2002, fresh weight yields were recorded and then samples of grain and beans from each plot were analysed for dry matter, total nitrogen, phosphorus and potassium, crude protein content and 1000 grain/seed weight, as indicators of crop quality.

Soil samples were also taken on 29th August 2002 from each plot immediately following harvest and analysed for the same range of nutrients and metals as carried out just after the crops were drilled to provide an indication of residual nutrient/metal levels in the soil.

With the exception of the pest and disease scores and weed assessments, data for each parameter was analysed using the interactive statistics software 'INSTAT Plus for Windows (version 1.5.1 trial, Copyright 2001, Statistical Services Centre, University of Reading). Initially each parameter was analysed using a simple analysis of variance (ANOVA) procedure. For those parameters which were found to show a significant treatment effect, a generalised linear model procedure was used to investigate the factorial structure of the results and assess trends. The pest and disease scores were assessed by comparison of mean scores. Weed assessments were analysed using GENSTAT 5th edition statistics software (version 4.21) using a simple ANOVA approach. The results from each crop were analysed and reported separately for each parameter.

3.0 Results and discussion

3.1 Compost analysis

Table 2 shows results of nutrient and heavy metal analyses from the different GROWS composts. In the final report for part one of the GROWS project, major nutrient levels in the three GROWS composting systems were compared against typical values found in other common bulky organic materials (Pickering and Bulson, 2002). Compared on a dry weight basis, the GROWS composts all supplied similar levels of total nitrogen, and more total phosphorus and potassium compared to stacked organic cattle manure. Relative to green waste compost, the GROWS composts all supplied noticeably more nitrogen, phosphorus and potassium. However, on a fresh weight basis the comparisons are somewhat different due to the differences in moisture content typically encountered at application.

Table 3 compares the nutrient composition of different bulky organic materials and at the bottom presents the total amount of major nutrients applied in a standard application of 25 tonnes of fresh compost or manure. Because of differences in dry matter content, the GROWS composts supply a similar amount of nitrogen compared to green waste compost and slightly more than stacked organic cattle manure *on a fresh weight applied basis*. However in terms of total phosphorus and total potassium, the GROWS composts supply approximately twice the amount of phosphorus and potassium per fresh tonne than stacked organic cattle manure. With respect to green waste compost, the GROWS composts supply four times the amount of total phosphorus and three times the amount of total potassium for a given fresh weight.

Analysis	GROWS Open Windrow Compost	GROWS Gore® System Compost	GROWS BioSal In-vessel Compost	Stacked Organic Cattle Manure[1]	Green Waste Compost[2]
Age of Organic Material	>12 weeks	>12 weeks	>12 weeks	≥12 weeks.	12 weeks
Dry Matter (%)	34.5	32.5	31.0	20.6	60.0[3]
Total Nitrogen (%w/w)	1.78	1.96	1.91	2.02	1.0
Total Phosphorus (% w/w)	0.88	0.77	1.04	0.4	0.2
Total Potassium (%w/w)	2.71	2.73	3.01	2.5	0.5
Amount of major nutrients applied in a typical 25t/ha application of fresh material					
Total Nitrogen (kg/ha)	154	159	148	104	150
Total Phosphorus (kg/ha)	220	193	260	100	50
Total Potassium (kg/ha)	234	222	233	129	75

[1] Data from Shepherd *et al*, 1999.
[2] Data from Composting Association , 2001.
[3] Typical values for 12 week-old green waste compost produced by open windrow composting

Table 3. Major nutrient analyses from GROWS composts and two common alternative bulky organic materials – farmyard cattle manure from an organic farm and civic amenity green waste (made from composted park and garden waste). Data is given on a dry weight basis and also as the amount of nutrient applied (in kg/ha) in a fresh weight application of 25 tonnes/ha.

With the exception of copper levels in open windrow compost, the heavy metal level results all fall below the maximum permitted heavy metal levels allowed in manures, as laid down in the Soil Association Standards for Organic Farming and Production (Soil Association 2002). The copper result for open windrow compost is unexpectedly high. There is no simple explanation for this since all previous analyses done during the trial suggested levels in the same order as those presented for the Gore® and BioSal composting systems. It is suggested that this single outlying result is probably due to sampling error.

3.2 Soil analysis

Soil analysis was carried out on the trial plots after compost application but prior to sowing (Autumn 2001) and again at harvest (Autumn 2002) to determine if either the different types or the different rates of compost applied, significantly affected soil pH, soil organic matter, available nutrients or total heavy metal levels present in the trial plots.

Heavy metals and pH were not significantly affected by the applied treatments *i.e.* the application of compost did not alter soil pH or heavy metal levels relative to the control plots which received no compost. However there were statistically significant treatment effects relating to soil organic matter and available nutrient levels in both the triticale and winter bean trials.

Figures 1 and 2 illustrate the effects on available nutrient levels and organic matter in the soil of the triticale field trial plots related to increasing rates of compost application. In all cases except organic matter levels recorded at harvest there is a significant positive effect (i.e. levels of nutrients increase) with increased compost application irrespective of the type of compost applied.

Tables A1 and A2 in Appendix 1 provide more detailed information allowing statistical comparison of treatment means. However, it can be seen from Figures 1 and 2 that compost application raises the level of available phosphorus, potassium, and to a lesser extent magnesium and organic matter in the soil. These increases are broadly proportional to the amount of compost applied. For available phosphorus and potassium, and less so for available magnesium, this trend is still observable one year after compost application following the harvest of a crop of triticale. This suggests that there is some residual benefit in terms of available nutrients from application of this compost.

Organic matter levels increased in response to compost application at the start of the trial. However, levels were not found to be significantly higher, relative to the control plots one year later at harvest. This could be attributed to assimilation of the organic matter into the soil during the growing season or oxidation of the material left on the soil surface.

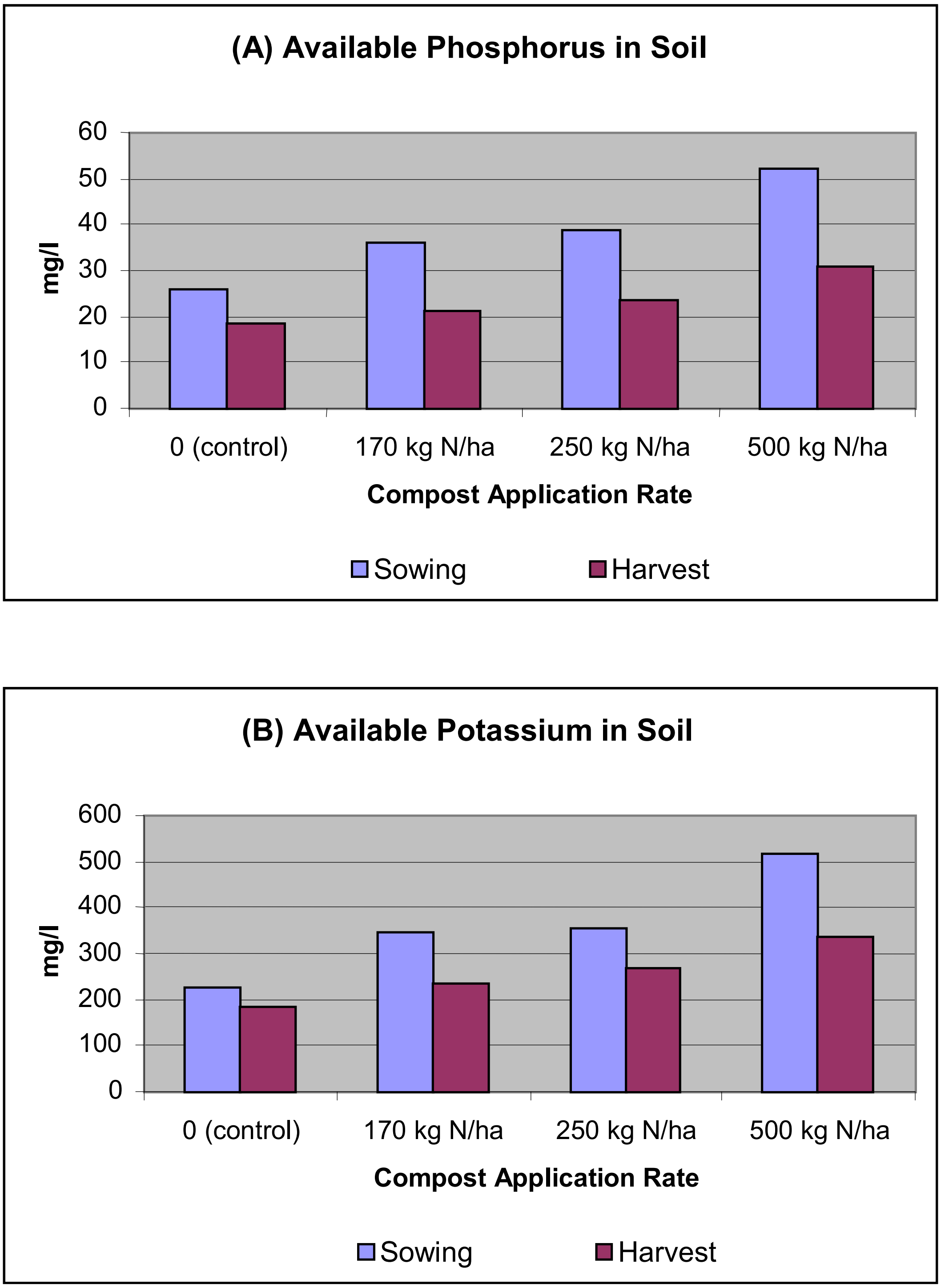
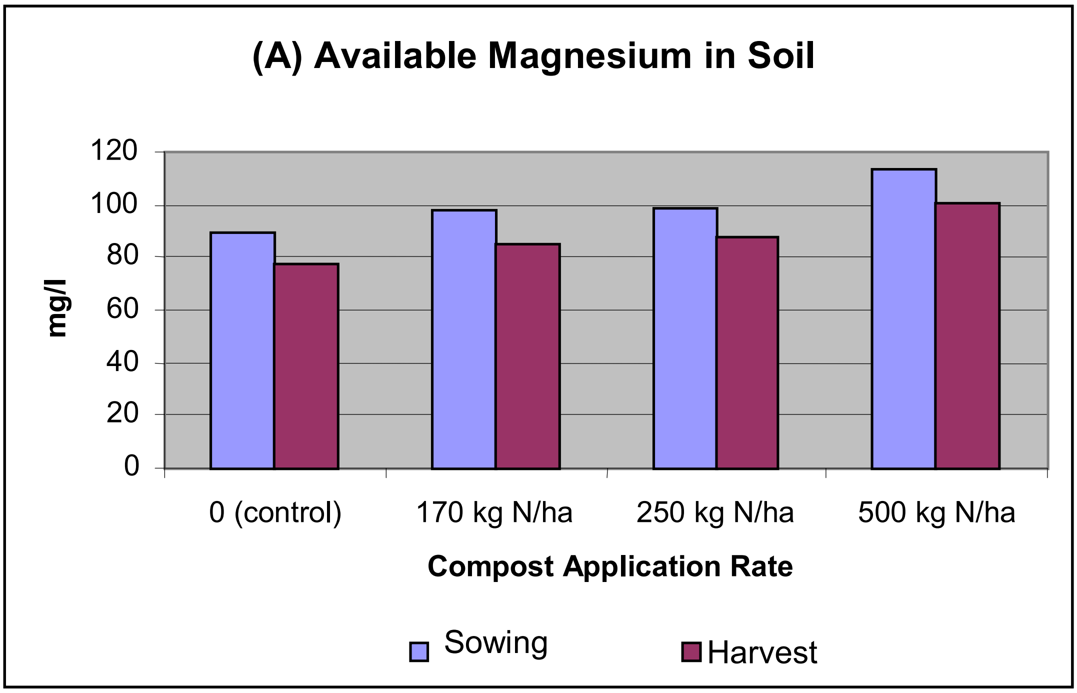


Figure 1. Available phosphorus levels (A) and available potassium levels (B) in the soil of the triticale field trial plots prior to sowing (autumn 2001) and at harvest (autumn 2002).



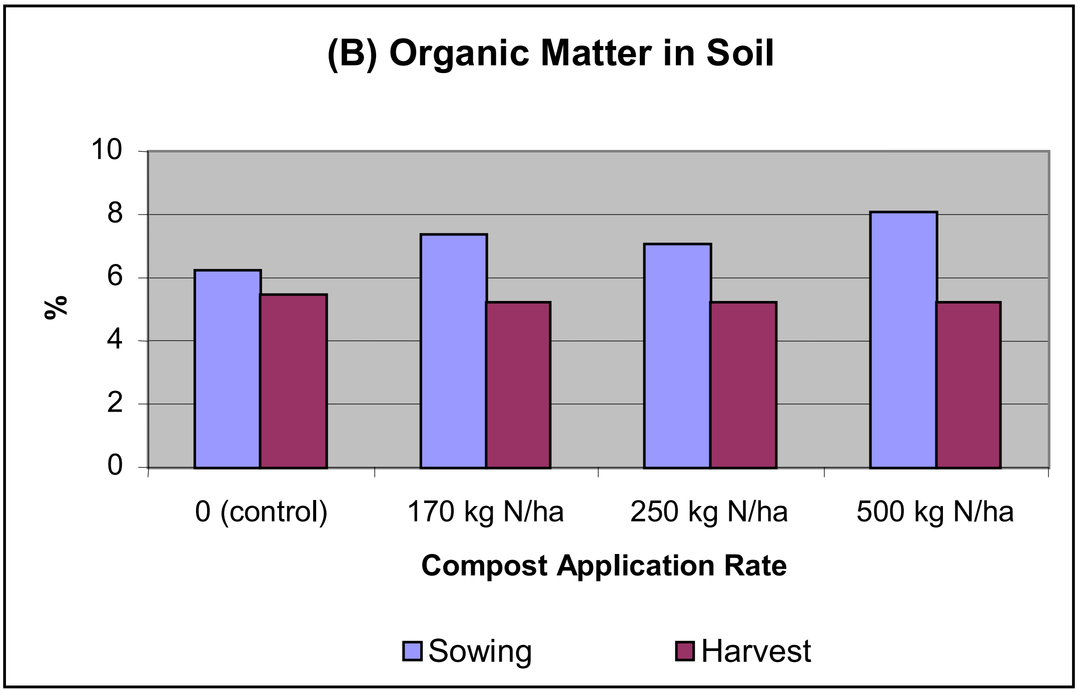


Figure 2. Available magnesium levels (A) and organic matter levels (B) in the soil of the triticale field trial plots prior to sowing (autumn 2001) and at harvest (autumn 2002).

It should be noted that although statistically significant effects were observed for all the above-mentioned parameters, when the differences between individual treatment means were statistically analysed the following observations were made:

- The most pronounced differences relative to the control plots were observed at sowing rather than at harvest.
- Available phosphorus and potassium levels were more positively affected by increased compost application than available magnesium or organic matter.
- Treatment effects were more marked relative to the control (i.e. treatment differences were more statistically significant) at the highest compost application rate (500kg N/ha equivalent) than at the lower rates.

Compost type had a much smaller impact on the soil parameters measured. Available phosphorus in the winter bean trial was the only parameter found to show a significant treatment effect at sowing. In this case the control plots had the lowest mean level, followed by the open windrow plots and the Gore system plots with the Biosal plots showing the highest levels. This trend was also observed for available phosphorus and available potassium in the winter bean trial at harvest and for available phosphorus in the triticale trial at harvest. The most likely explanation for these differences, and in particular the significant positive effect of the BioSal compost on nutrient levels relative to the other treatments is that this compost contained high phosphorus and potassium levels when applied (table 3) and that some of the Biosal compost had been stored for a shorter period than the other two types prior to application, and hence, was likely to have been subjected to less leaching of available nutrients by the rain.

Soil analysis data relating specifically to the winter bean trial is presented in less detail here, since the trends observed were broadly similar to those described for the triticale trial. However details of soil analysis treatment means for both trials are provided in Appendix 1.

3.3 Crop emergence

Analysis of emergence data from each crop revealed that neither the type of compost, nor the amount applied had any significant effect on the numbers of seedlings emerged when compared with the zero compost control. The average population for each crop was 216 plants/m^2 for triticale and 24 seedlings/m^2 for winter beans when monitoring was done in early January 2002. These results compare with an optimum of 250 plants/m^2 and 25 plants/m^2 for triticale and winter beans respectively. It is not unusual to have lower populations in trial situations and the results obtained were considered satisfactory, given that the main interest was the comparison between treatments within each crop trial.

3.4 Weed growth

3.4.1 Triticale

3.4.1.1 Assessments 03-April-02

Overall, weed population density was very low throughout the trial, with an average total weed density of 21.7 weed m^{-2}. The main weed species comprised (in order of most occurrence): *Poa annua* (annual meadow grass), *Alopecurus myosuroides* (blackgrass), *Papaver rhoeas* (corn poppy), *Stellaria media* (chickweed) and *Veronica persica* (speedwell).

With the exception of annual meadow grass and total weed density, the weed density data were skewed from a normal distribution, preventing analysis of variance. However, neither annual meadow grass nor total weed density was significantly ($P \leq 0.05$) affected by the treatments and was not significantly different from the control plots (Fig. 3).

3.4.1.2 Assessments 21-May-02

Weed populations remained at a low density at the second sampling date, with an average total weed density of 18.0 weeds m^{-2}. The main weed species present (in order of most frequent occurrence) were: *Poa annua* (annual meadow grass), *Veronica persica* (speedwell), *Papaver rhoeas* (corn poppy), *Stellaria media* (chickweed), *Cirsium* spp. (thistle), *Alopecurus myosuroides* (blackgrass), *Viola arvensis* (field pansy), *Chenopodium album* (fat hen), *Galium aparine* (cleavers) and *Polygonum* spp.

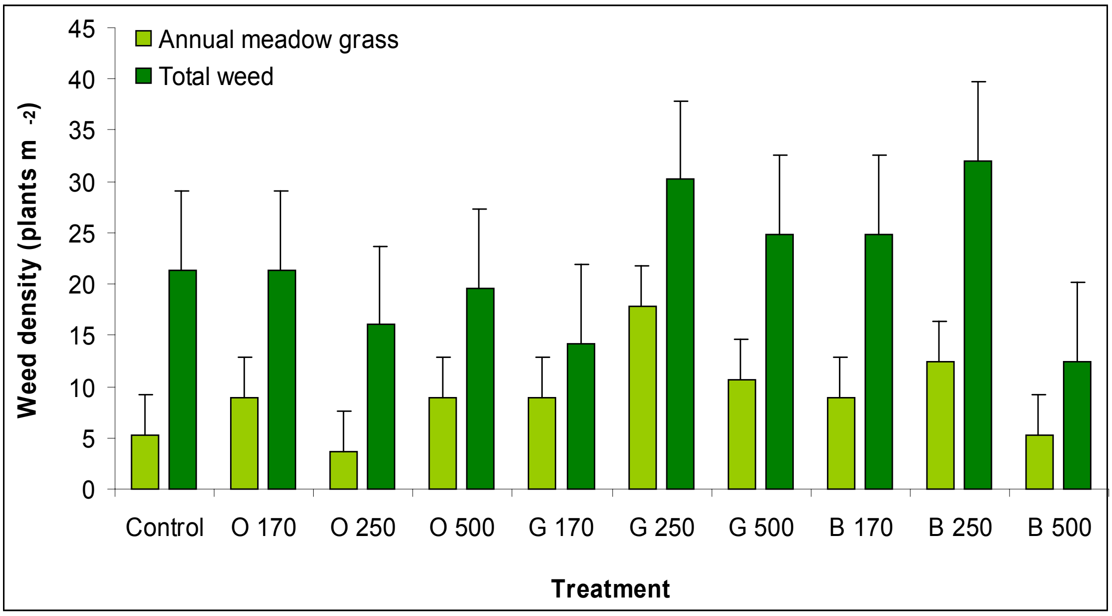


Figure 3. The effect of compost applications on annual meadow grass and total weed density in a triticale crop when assessed on 03-April-2002. Error bars represent the estimated standard error of the means.

Statistical analysis was restricted to annual meadow grass, speedwell and total weed density. Again, no statistically significant differences were found between the compost treatments or between the treatments and control plots (Fig. 4).

3.4.2 Winter field beans

3.4.2.1 Assessments 03-April-02

Weed population density was generally low throughout the experiment, with an average total weed density of 19.2 weed m^{-2}. The main weed species comprised (in order of most frequent occurrence): *Poa annua* (annual meadow grass), *Papaver rhoeas* (corn poppy), *Alopecurus myosuroides* (blackgrass), *Veronica persica* (speedwell) and *Stellaria media* (chickweed). Statistical analysis was restricted to annual meadow grass and total weed density. Unlike triticale, statistical differences were observed between treatments and also between treatments and the control plots (Fig. 5).

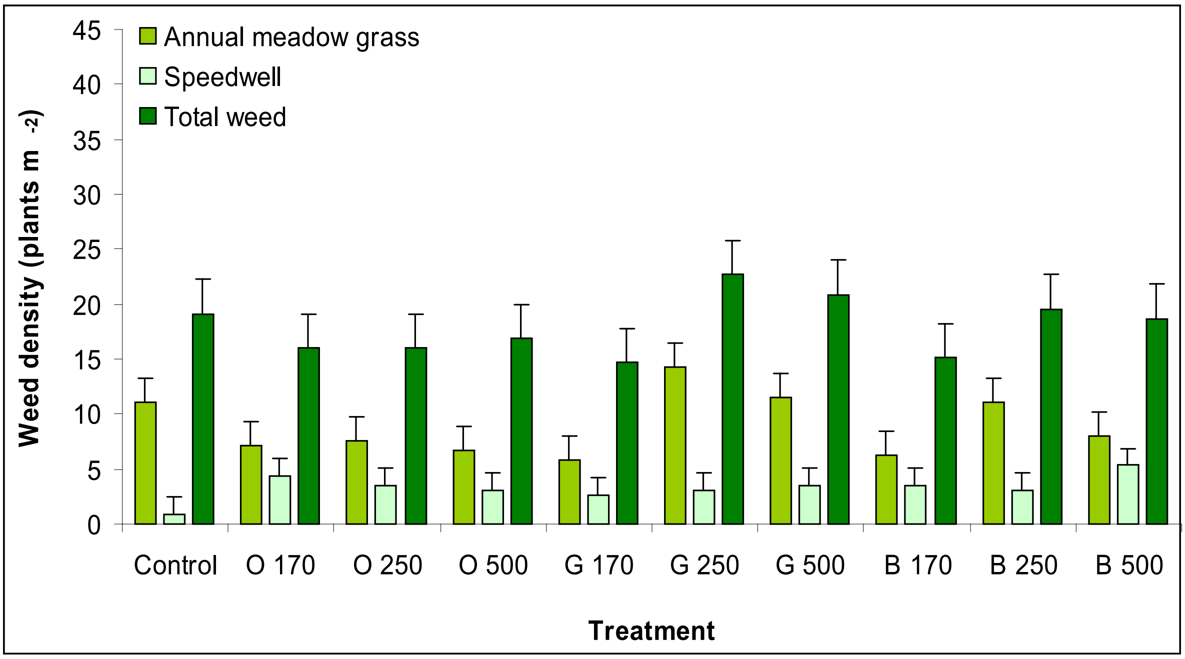


Figure 4. The effect of compost applications on annual meadow grass, speedwell and total weed density in a triticale crop when assessed on 21-May-2002. Error bars represent the estimated standard error of the means.

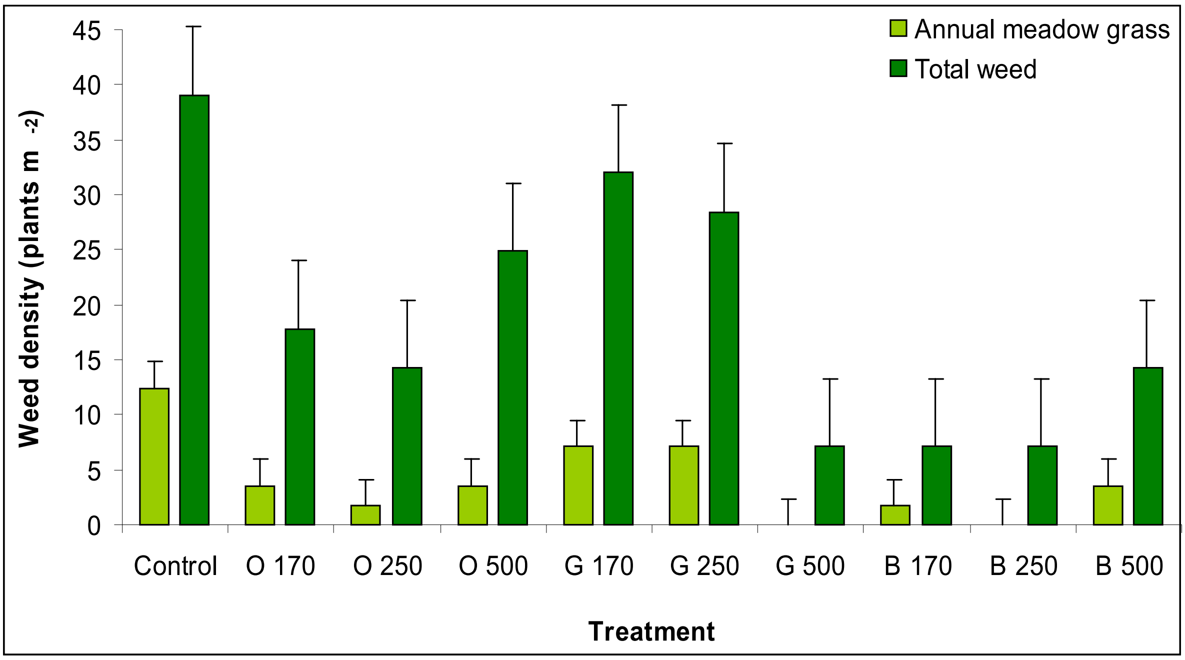


Figure 5. The effect of compost applications on annual meadow grass and total weed density in a winter bean crop when assessed on 03-April-2002. Error bars represent the estimated standard error of the means.

In terms of annual meadow grass, all compost application treatments, with the exception of G170 and G250, (see Table 1. for treatment codes) had a significantly (P = 0.036) lower population density than the untreated control plot (Fig. 5). All of the treated plots, however, had a lower *total weed* population density than the control. When considering differences between treatments, G500 and B250 had significantly (P = 0.036) lower population densities than either G170 or G250. The remaining treatments were not significantly different from each other.

In terms of total weed density, all compost application treatments, with the exception of O500, G170 and G250, had a significantly ($P = 0.013$) lower population density than the untreated control treatment (Fig. 5). When considering differences between treatments, G500, B170 and B250 had significantly ($P = 0.013$) lower population densities than either G170 or G250. The remaining treatments were not significantly different from each other.

3.4.2.2 Assessments 21-May-02

Weeds remained at low levels at the second sampling date, with an average total weed population density of 14.1 weeds m^{-2}. The main weed species present (in order of most frequent occurrence) were: *Poa annua* (annual meadow grass), *Papaver rhoeas* (corn poppy), *Stellaria media* (chickweed), *Polygonum* spp., *Chenopodium album* (fat hen), *Veronica persica* (speedwell), *Alopecurus myosuroides* (blackgrass), *Cirsium* spp. (thistle) and *Viola arvensis* (field pansy).

Statistical analysis was restricted to annual meadow grass and total weed density. A significant response was only observed for total weed density (Fig. 6). In this case, only B500 had a significantly ($P = 0.013$) lower population density than the control plot. When comparing differences between treatments, O500 had a significantly greater total weed density than all other compost application treatments with the exception of O170 and G250.

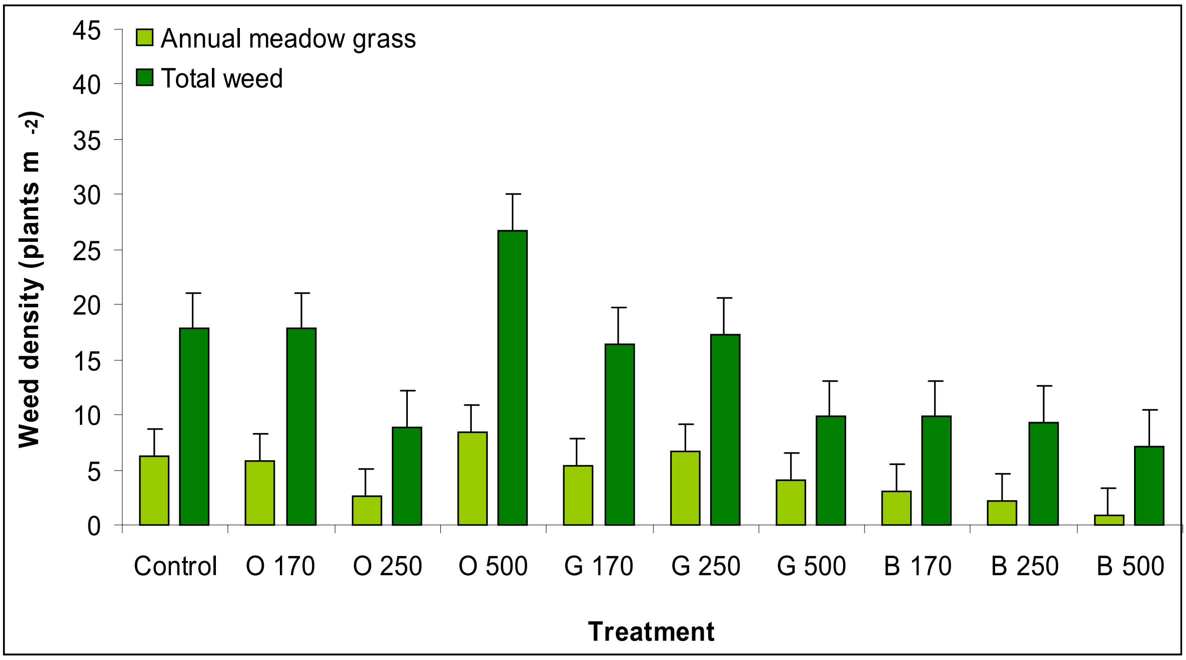


Figure 6. The effect of compost applications on annual meadow grass and total weed density in a winter bean crop when assessed on 21-May-2002. Bars represent the standard error of the means.

3.4.3. Discussion

Generally, weed population density was low at both sampling dates in both crops. At these levels, the weed populations would be unlikely to significantly affect final crop yield.

There was no significant difference in weed levels between compost application treatments in the triticale trial; however, differences were noted in the winter bean experiment, although the data were inconsistent between assessments dates. The data do not show any clear trends relating either to compost type or application rate. Where significant treatment effects were observed (in the winter bean trial) it appeared that compost application possibly reduced total weed density relative to the control. This could have been due to a physical 'mulching' effect of the compost itself, although further studies would be needed to support this since at the lower application rates very little compost was actually applied and the result was not consistent across sampling dates. In this study it was more likely that to a large extent the sampling picked up natural variations in weed populations in the soil and effects due to applied compost were probably masked to a large extent.

What was clear from the results was that no exotic species were observed, suggesting that none of the fruit, vegetables or cut flowers present in the compost feedstocks had released seeds which survived the composting process. In addition, the application of compost did not appear to stimulate existing weed seeds in the trial plots to establish better than in the control treatments, nor did the different composts appear to provide a 'welcoming environment' for wind-blown seeds to accumulate in prior to spreading.

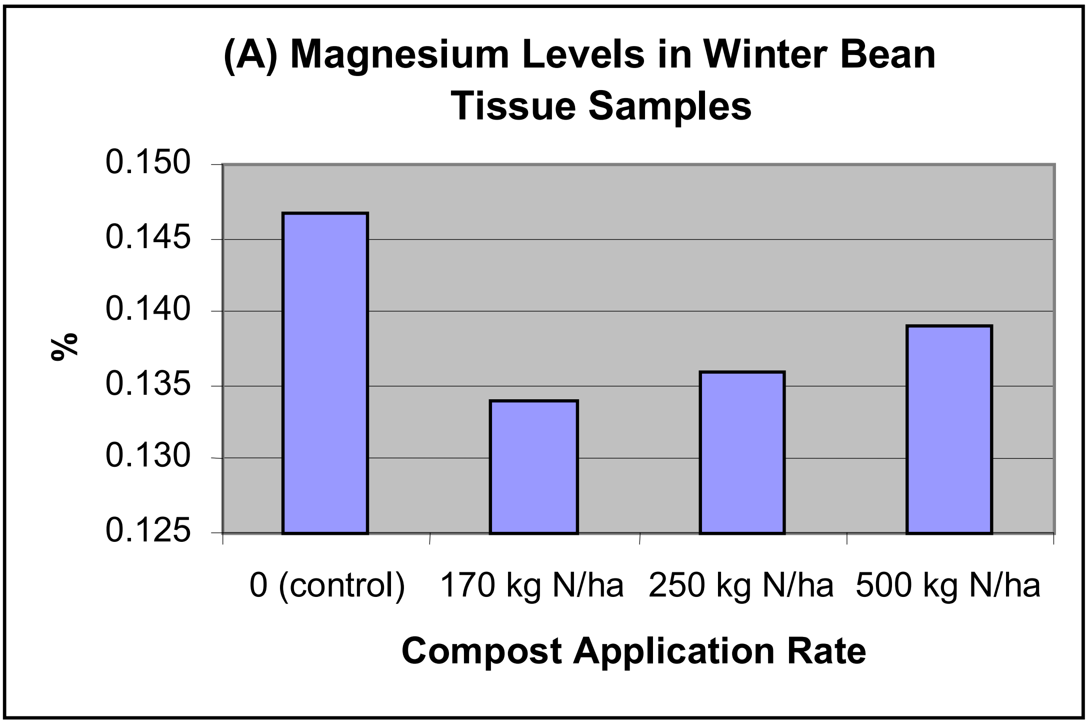
3.5 Tissue analysis

Samples of plant tissue from each crop were taken in May 2002 and nutrient analysis carried out to determine if the type of compost or the amount applied resulted in significant differences between the treatments and the zero control plots. Nine nutrient elements were tested for: nitrogen, phosphorus, potassium, magnesium, calcium, manganese, copper, zinc and sulphur. In the triticale trial there was no significant effect in any of the treatments relative to the control treatment. In the winter bean trial however, the analysis results revealed that applying compost reduced the amount of magnesium and manganese in the plant tissues (Figure 7). There was a statistically significant reduction in tissue magnesium ($p = <0.01$ and $p = <0.05$) in the two lowest compost treatments (170 and 250 kg N/ha/year respectively) relative to the control treatment and a significant reduction in tissue manganese ($p<0.05$) in the highest compost application treatment (500kg N/ha/year) relative to the control.

The reduced tissue levels of magnesium could be a response to the applied compost treatments being relatively rich in potassium. It is well known that under potassium-rich soil conditions, magnesium uptake by plants can be inhibited (Archer, 1988) and this could explain the results here.

With respect to the reduced tissue levels of manganese, this nutrient becomes less available for plant uptake under alkaline conditions. The field trial soils were naturally alkaline and although the soil analysis data did not reveal a significant impact on soil acidity or alkalinity, the application of mature compost can often have a slight additional liming effect on the soil. It is suggested that the reduced tissue manganese levels observed in the winter beans could be a result of this phenomenon.

There were no consistent treatment effects with respect to the type of compost applied.



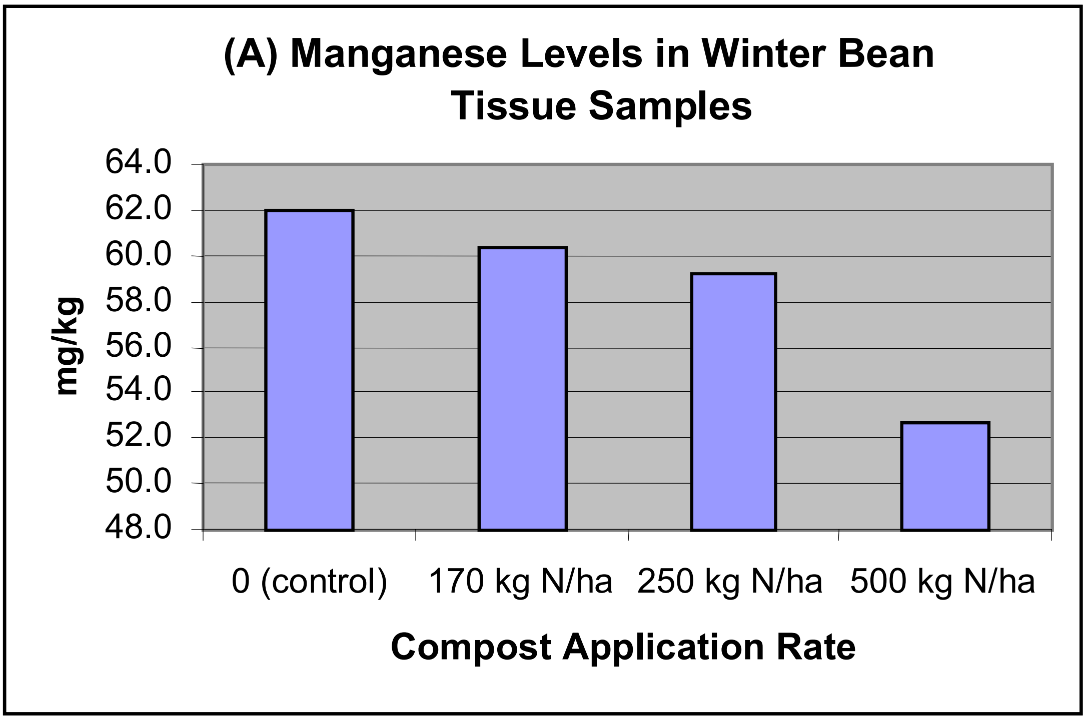


Figure 7. Tissue levels of (A) magnesium and (B) manganese in samples of winter beans taken in May 2002.

3.6 Pests and disease

Pest and disease incidence in each crop was assessed in early July 2002. There was little evidence of either pests or disease in the triticale crop. Plate 4 shows how the triticale trial area is indistinguishable from the surrounding triticale grown in the field where the trials were located.

In the winter beans however, there was evidence of both pests and disease. Early in the trial it was suspected that bird damage would occur – it is well known that bean seed is favoured as a food source especially by rooks. Birds will often dig down to retrieve the seeds after sowing, or pull up the recently germinated plants to get at the beans and soil-living creatures beneath the plants. Despite control measures described in section 2.0, it was thought that bird damage had significantly reduced the plant density in the winter bean trial. Emergence monitoring in January suggested that the plant density was satisfactory, but it is thought that further damage occurred after the monitoring date leading to low plant density in Block 3 and reduced density in Block 2 of the trial (Plate 5).

The bean plants which had survived bird damage were then subjected to attack by pea and bean weevil (*Sitona lineatus*) which also occurred when the plants were young. Evidence for this was provided by the obvious notches nibbled in the margins of the lower leaves, although there was no evidence of any weevils when the assessment was made. There was a small amount of black bean aphid (*Aphis fabae*) present and some banded snails (*Cepaea sp*) were also observed but in very low numbers.

With respect to disease, the main problems observed were some bean chocolate spot (*Botrytis fabae*), a lot of bean rust (*Uromyces viciae-fabae*) (Plate 6) and a small number of plants with symptoms of plant virus. Qualitative scoring of both the pests and diseases showed that the bean rust was by far the most significant problem, but neither with the rust nor the other diseases or pests was any trend obvious which linked the severity of the pest or disease with the applied treatments. Instead, the dispersal of the pests and disease throughout the bean trial appeared quite random.

Plate 4. Aerial view of triticale trial. Both the triticale and the winter bean trials were located in a field where the main crop being grown was triticale – this is why the boundary between the trial triticale and main crop is all but invisible.

Plate 5. Aerial view of winter bean trial. Note lower plant density due primarily to bird damage in block 3 (to the right of the picture).

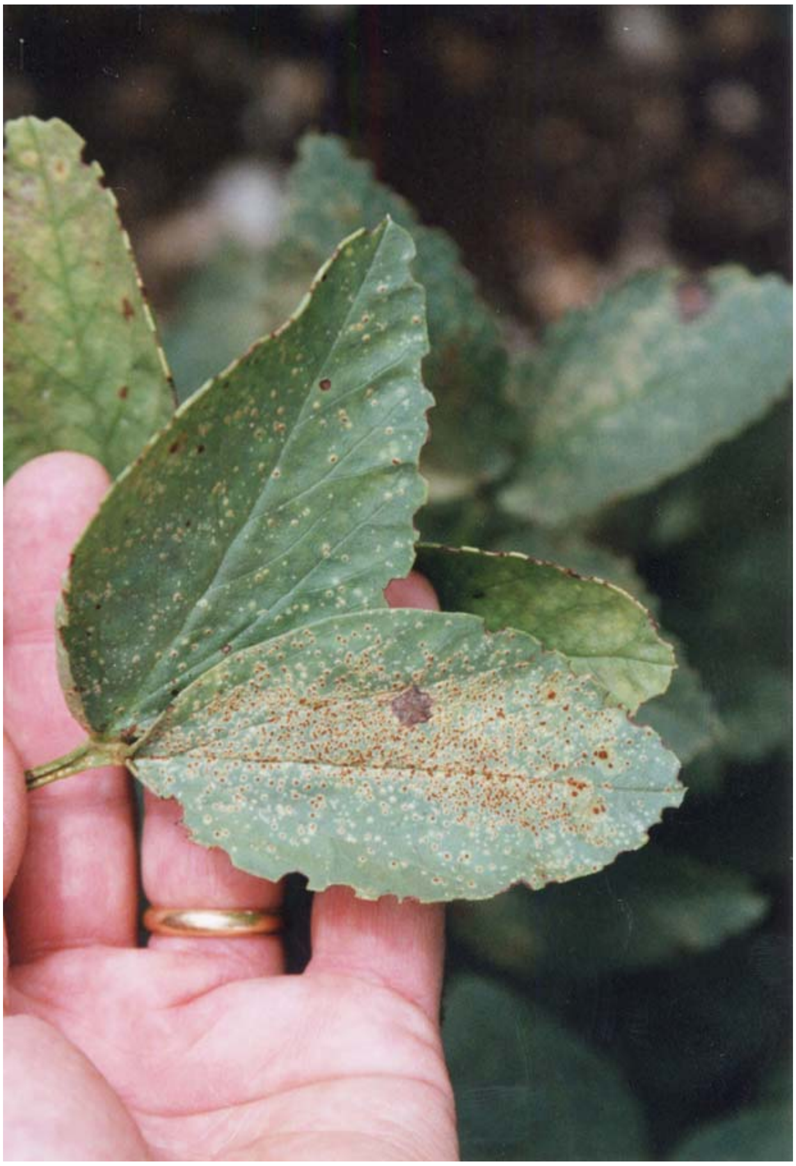


Plate 6. Close up showing pest and disease damage to winter bean trial plants. Bean weevil damage can be seen as notches around the leaf margin, bean rust shows as fine orange-brown spots and chocolate spot as the larger brown lesions especially visible on the top leaf.

3.7 Crop yield

Both trials were harvested at the end of August 2002. Unfortunately, bird damage early in the season and disease in the spring and summer meant that a portion of the crop was badly damaged and yield from a number of plots was very patchy. On analysing the winter bean yield data the results were inconclusive. Because of this, only yield data from the triticale trial is presented here.

Yield was measured by weight of grain harvested, adjusted to a uniform moisture content and quality was assessed using thousand grain weight and crude protein content. In addition, phosphorus and potassium content of the grain was determined to try to establish if there was any link between these major nutrients and the yield in the applied treatments.

Compost type did not affect yield but increasing compost application rate significantly increased yield ($P<0.01$) at the highest rate of application relative to the control (Figure 8).

There was no significant impact by the treatments on thousand grain weight, crude protein content, total phosphorus content or total potassium content relative to the control.

The increased yield at the highest compost application rate could have been due to increased availability of nutrients provided by the compost. This is supported by the elevated levels of P and K in the soil observed both after compost application and at harvest. Analysis of the grain at harvest did not identify higher P or K contents at the higher compost application rates, although the nutrients may have been used in root or leaf growth rather than grain development.

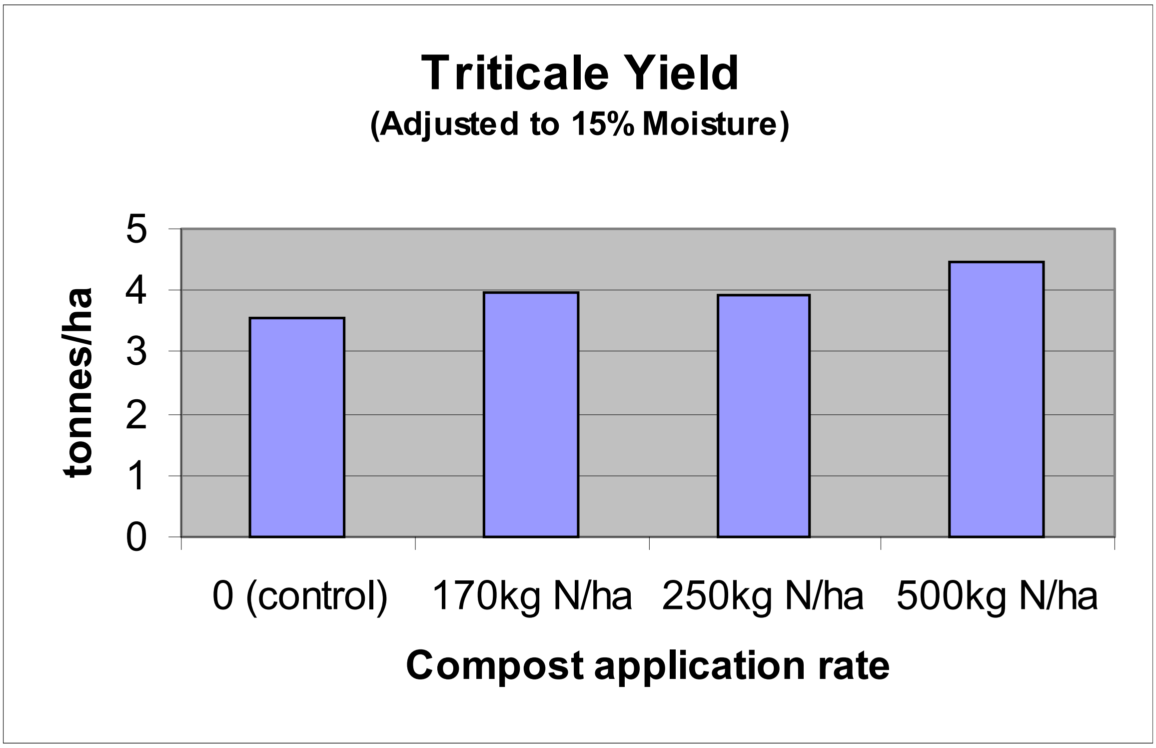


Figure 8. Triticale yield at harvest showing increase in yield due to increasing compost application rate.

4.0 Economic value of GROWS compost

The most realistic way of determining the value of the compost in this type of one-year field trial is to calculate the financial gross margin produced by the sale of the grain. Table 4 summarises how this might be calculated.

	Control **0 N/ha/yr**	**170 N/ha/yr**	**250 N/ha/yr**	**500kg N/ha/yr**
Output[1]				
Grain yield (t/ha)	3.56	3.95	3.95	4.47
Grain value (£/t)	165.00	165.00	165.00	165.00
Crop value (£/ha)	**587.40**	**651.75**	**651.75**	**737.55**
Inputs				
Seed costs (£/ha) (250kg/ha @ £490/tonne)	**122.50**	**122.50**	**122.50**	**122.50**
Compost applied (fresh tonnes/ha)	0.00	27.70	40.70	81.40
Cost of compost application (£/ha)[2]	**0.00**	**55.50**	**55.50**	**111.00**
Gross margin (£/ha) (Output – Inputs)	**464.90**	**473.75**	**473.75**	**504.05**

[1] Outputs are calculated without inclusion of any government subsidies

[2] Application of bulky organic matter is not an exact science, and calculating exact costs/tonne applied is difficult as the farmer rarely knows precisely how much is applied – instead costings are usually calculated in £/hr. However, using the machinery at Sheepdrove Organic Farm it was calculated that an application rate of 37 tonnes/ha of bulky organic matter could be costed at £55.50/ha. It was estimated that the two lowest compost application rates used in the trial would take approximately the same time and man-power, but that the highest rate would take double the time to achieve, hence the entries given in the table.

Table 4. Gross margin associated with the sale of organic triticale grain for animal feed, allowing for the different compost application rates used in the GROWS field trial.

After one year, the financial benefit of applying compost, relative to the zero compost control treatment is estimated to be £8.85/ha for the two lower compost application rates and £39.15 for the highest application. It is important to recognise that in organic systems and on conventional farms designated as being in a nitrate vulnerable zone (NVZ), the farmer is only permitted to apply the lowest compost rate (170kg N / ha / year) in order to avoid excessive nitrogen application. In these cases, the financial benefit obtained after one year is very small. There is evidence of residual benefit from compost application after the initial year, e.g. elevated P and K levels in the soil at harvest, but the financial implication of this is difficult to determine in a one year trial. Less tangible, longer-term improvements to soil workability, biological activity and disease resistance have been attributed to repeated compost applications in the literature, but assessment of these are beyond the scope of this piece of work.

5.0 Conclusions

5.1 Assessment of compost characteristics

- When compared on a dry weight basis, the three types of compost used in the trial (Open windrow, covered Gore® system and BioSal in-vessel system) differed only slightly. The BioSal compost appeared to have a slightly higher phosphorus and potassium content which was attributed to the fact that it had not been stored as long as the other two types of compost before use and may therefore have been exposed to less leaching by the rain.
- All the GROWS composts contained more nitrogen than green waste compost and more phosphorus and potassium than both green waste compost and cattle manure from organic farms, when compared on a dry weight basis.

5.2 Impacts on the soil

- Application of the composts to the field plots resulted in a positive response in terms of available phosphorus, potassium, magnesium and organic matter. Increasing rates of compost led to significant increases in the levels of the above parameters immediately after compost application and elevated levels of available phosphorus and potassium were still detectable at harvest one year later.

5.3 Weed growth

- The use of the GROWS composts did not introduce exotic weeds into the organic farming system. It appeared that although viable seeds were present in the raw waste (from the fruit and vegetable matter), these did not survive the composting and maturation process prior to being applied to the land.
- Application of the composts did not stimulate existing weeds by supplying supplementary nutrition, or more favourable soil conditions for improved germination.

5.4 Pests and disease

- No pests or disease were observed in the triticale trial.
- Although pest and disease was observed in the winter bean trial, there was no indication that these were linked to any of the applied compost treatments.

5.5 Crop growth

- The compost treatments did not have any significant effect on crop emergence.
- Increasing the *rate* of compost application led to an increase in grain yield from the triticale trial. This increase in yield relative to the control was found to be statistically significant ($p<0.01$) at the highest level of compost application. However, there was no significant impact on crop yield due to the different *types* of compost used in the trial.

5.6 Economic benefits of compost application

- Economic benefit of the compost treatments was assessed by calculating the financial gross margin produced from the sale of the triticale grain yield under each of the compost treatments. Once the cost of applying the compost was taken into account, the financial benefit of £9.00/ha was very small at the two lowest rates of application. However, at the highest rate of application the increase in gross margin to £39/ha meant that the benefit was then considerable. It should be noted that the value of the compost, when calculated in this way is dependant on the yield and value of the crop being grown. For a more accurate analysis of value, calculations should be made over a whole crop rotation, although this would mean carrying out trials over an extended period of several years.

- If the cost of application of the compost is calculated per tonne it corresponds approximately to £1.30 – £2.00/tonne of fresh compost applied. If it is assumed that one tonne of raw input material makes approximately 0.5 tonnes of finished compost, this means that the gate fee charged for processing the original input waste material must be raised by £0.65 - £1.00/tonne to cover the cost of spreading the applied compost (assuming it is applied at the same site at which it is produced and no transportation costs are incurred).
- Based on the costs of collection and composting estimated in the Part 1 GROWS Project report (Pickering and Bulson, 2002), the above assumption would raise the combined cost of collection, composting and application using the GROWS model to £49.32-£49.67/tonne of input material (assuming the cheapest process option - bread excluded from supermarket waste and open windrow composting). This compares with £38.00/tonne - the estimated cost of collecting the mixed supermarket waste and landfilling it, giving a difference of approximately £11.50/tonne. Therefore, when compared against landfilling, the collection of source-separated supermarket fruit and vegetable waste in a rural catchment area, its composting, and application to land is not economically viable. This will not change significantly until:

a) Collection and landfill charges of mixed waste increase to a point which is closer to the costs of the GROWS model.
b) Collection costs of source separated supermarket waste can be reduced, perhaps by combining waste collections from different sectors.
c) Grain prices increase significantly, thereby providing more of an incentive for farmers to make and apply compost to land to raise yields.
d) Other legislative drivers or subsidies make source separation/composting more attractive than landfilling of mixed waste, e.g. a subsidy based on soil carbon content becoming available within the context of any proposed EU soils strategy.

5.7 Summary

Compost manufactured from supermarket waste was found to be relatively low in contaminants and contained favourable levels of major nutrients when compared with other common bulky organic soil amendments, regardless of the type of composting system used. GROWS compost did not lead to the introduction of exotic weeds or the direct incidence of major pests or disease. Yields were increased through application of the compost in the case of triticale, although only at the highest rate was this yield increase statistically significant. Similarly, only at the highest compost application was the financial benefit useful, and this has to be balanced against the fact that in many situations high application rates of compost (500kg nitrogen /hectare/year) will not be possible due to regulatory restrictions (e.g. organic production legislation and the restrictions due to Nitrate Vulnerable Zones - NVZs). Lower rate applications of compost, within the 170kg N /ha/year limit are unlikely to be cost effective based solely on short term gross margin calculations. Over the longer term, this work supports the findings of others who conclude that repeated compost applications are likely to be beneficial through the gradual improvement of soil fertility. However, trials spanning a whole crop rotation or longer would be needed to assess this.

In the opinion of the authors, the findings of this report support the view that the economic value of GROWS compost, applied in accordance with existing regulations as a general agricultural soil conditioner, is insufficient to allow any additional revenue generated directly from utilising the compost to be offset against the cost of the compost's production. Its utilisation for alternative, higher value end uses may change this position, although in these situations there is likely to be a concurrent increase in processing costs to obtain the higher specification end-product required. When compared against landfilling, the GROWS model remains more expensive and this will not change unless one of the scenarios suggested in section 5.6 takes effect.

6.0 References

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7.0 Appendices

Appendix 1. Summaries of statistical analysis

In this appendix the means and standard errors from the analyses of those parameters which revealed a statistically significant treatment effect are presented.

Triticale	Sowing				Harvest			
	Av. P mg/l	**Av. K** mg/l	**Av. Mg** mg/l	**O.M.** %	**Av. P** mg/l	**Av. K** mg/l	**Av. Mg** mg/l	**O.M.** %
Control	25.9	228.3	89.33	6.2	18.53	183.7	78.0	5.5
Rate	❋❋❋	❋❋❋	❋❋❋	❋❋	❋❋❋	❋❋❋	❋	**N/S**
170 kg N/ ha	35.8	347.3	97.7	7.4	21.4	237.5	84.6	--
250 kg N/ ha	38.8	355.3	98.8	7.1	23.6	266.9	88.0	--
500 kg N/Ha	52.3	517.6	113.6	8.1	30.9	337.3	100.2	--
Type	**N/S**	**N/S**	**N/S**	**N/S**	❋❋	**N/S**	❋❋❋	**N/S**
Open Windrow	--	--	--	--	21.6	--	87.2	--
Gore System	--	--	--	--	25.1	--	95.1	--
In-Vessel	--	--	--	--	29.1	--	90.4	--
Rate x Type Interaction	**N/S**	**N/S**	**N/S**	**N/S**	**N/S**	**N/S**	**N/S**	**N/S**
SED[1]	3.721	37.522	5.280	0.423	2.449	30.817	7.072	0.466
SED[2]	2.632	26.532	3.734	0.299	1.732	21.791	5.001	0.329

[1] To compare the Control mean with any other mean (18 degrees of freedom)
[2] To compare any Rate/Type mean with any other Rate/ Type mean (18df)

Table A1. Triticale trial treatment means for different soil parameters at sowing and at harvest. NB only parameters which revealed some significant treatment effect (P<0.05) are presented. ❋ = P< 0.05; ❋❋ = P = <0.01; ❋❋❋= P = <0.001; N/S = Not Significant (the smaller the P value, the greater the probability that observed differences are due to applied treatments rather than chance); SED = Standard error of differences – note that different comparisons require different SED.

Winter Beans	Sowing			Harvest		
	Av. P mg/l	Av. K mg/l	Av. mg mg/l	Av. P mg/l	Av. K Mg/l	Av. mg mg/l
Control	24.5	251.7	87.0	19.47	197.0	89.0
Rate	✵✵✵	✵✵✵	✵✵✵	✵✵✵	✵✵	✵✵
170 kg N/ ha	31.4	295.9	95.3	20.0	233.5	80.6
250 kg N/ ha	36.8	322.5	95.7	20.8	256.4	83.6
500 kg N/Ha	49.3	447.2	110.4	26.2	309.9	97.1
Type	✵✵	**N/S**	**N/S**	✵✵✵	✵✵✵	**N/S**
Open Windrow	36.8	--	--	20.9	239.0	--
Gore System	37.1	--	--	21.0	261.5	--
In-Vessel	43.5	--	--	25.2	299.3	--
Rate x Type Interaction	**N/S**	**N/S**	**N/S**	**N/S**	**N/S**	**N/S**
SED[1]	2.480	41.496	4.957	1.358	18.964	6.306
SED[2]	1.754	29.342	3.505	0.960	13.409	4.459

[1] To compare the Control mean with any other mean (18 degrees of freedom)
[2] To compare any Rate/Type mean with any other Rate/ Type mean (18df)

Table A2. Winter bean trial treatment means for different soil parameters at sowing and at harvest. NB only parameters which revealed some significant treatment effects (P<0.05) are presented. ✵ = P< 0.05; ✵✵ = P = <0.01; ✵✵✵= P = <0.001; N/S = Not Significant (the smaller the P value, the greater the probability that observed differences are due to applied treatments rather than chance); SED = Standard error of differences – note that different comparisons require different SED.

Triticale	**Yield at harvest** Tonnes/ha[1]	**Crude Protein Content[2]** %[3]	**Thousand Grain Weight** g/1000 grains[1]	**Grain P Content** %[3]	**Grain K Content** %[3]
Control	3.56	11.46	49.32	0.48	0.62
Rate	⁕	**N/S**	**N/S**	**N/S**	**N/S**
170 kg N/ ha	3.95	--	--	--	--
250 kg N/ ha	3.95	--	--	--	--
500 kg N/Ha	4.47	--	--	--	--
Type	**N/S**	**N/S**	**N/S**	**N/S**	**N/S**
Open Windrow	--	--	--	--	--
Gore System	--	--	--	--	--
In-Vessel	--	--	--	--	--
Rate x Type Interaction	**N/S**	**N/S**	**N/S**	**N/S**	**N/S**
SED[4]	0.0829	Not applicable	Not applicable	Not applicable	Not applicable
SED[5]	0.0415	Not applicable	Not applicable	Not applicable	Not applicable

[1] Adjusted to 15% moisture
[2] Crude protein = % N x 6.25
[3] Dry matter basis
[4] To compare the Control mean with any other mean (18 degrees of freedom)
[5] To compare any Rate/Type mean with any other Rate/ Type mean (18df)

Table A3. Triticale trial treatment means for yield results at harvest. ⁕ = P< 0.05; ⁕⁕ = P = <0.01; ⁕⁕⁕= P = <0.001; N/S = Not Significant (the smaller the P value, the greater the probability that observed differences are due to applied treatments rather than chance); SED = Standard error of differences – note that different comparisons require different SED.

Appendix 2. Publicising the GROWS project

Dissemination of information from the GROWS project was a very important aspect of the work. Details of publicity that has taken place since publication of the Phase 1 report are given below.

Lectures and presentations

- Campden & Chorleywood Food Research Association Group in collaboration with the Food and Drink Subject Interest Group of the IChemE Conference : Waste Minimisation – effective management of waste in food processing. November 2002 – presentation on the GROWS project by Dr Jon Pickering.
- GROWS project awarded second Place in the National Green Apple Awards for Environmental Best Practice 2002 under the CIWM composting category – November 2002.
- Biowise Conference - ENABLE: Processes, products and new solutions. *Biotechnology applications in manufacturing industry.* Edinburgh January 2003. Dr Hugh Bulson presented paper on GROWS project.

Website

Throughout the project there has been a website dedicated to the GROWS project (www.growscompost.co.uk) featuring general information about the project, questions and answers, details of the project partners, report summaries and how to contact the GROWS project.