COMPOST MARKET DEVELOPMENT PROJECT

Municipal Solid Waste Project # GRW/01/03 SEPTEMBER 2006

Forward

Every West Australian home generates approximately 1.3 tonnes of municipal solid waste (MSW) per household per year; of this waste material 0.71 tonnes is organic material. With some 700,000 domestic residences in Western Australia, this equals 490,000 tonnes of organic material, which traditionally has been disposed of in landfill.

In Western Australia the average organic matter in the topsoil ranges from 0.5% to 1.5%. There is a clear need for municipal solid waste organic material to be recovered and used to replenish the organic material in our poor soils.

With the above facts in mind, the Southern Metropolitan Regional Council (SMRC), resolved in 1999 to build a Municipal Solid Waste (MSW) composting facility to recover this lost organic material. The Western Australian State Government recognising the importance of this SMRC initiative provided a grant of $800,000 for the SMRC to develop the market for MSW based compost.

The project has been an outstanding success. For over two and half years 46 farms have used 20,000 tonnes of compost, made at the SMRC's Regional Resource Recovery Centre waste composting facility. The results achieved have been outstanding; improving yields, soil pH, soil health and 86% of the participating farmers stating they would continue to use compost.

This project has demonstrated conclusively that there is a strong demand for MSW-based compost amongst the farming community, and paves the way forward for other Regional Councils and MSW waste composting facilities to provide a sustainable solution for municipal waste management.

I would like to take this opportunity to acknowledge the Honourable Dr Judy Edwards MLA and former Minister for the Environment and Mr Noel Davies Chairman of the Waste Management Board, and the members of the project steering committee for their invaluable support on this project.

Cr Doug Thompson
Chairman
Southern Metropolitan Regional Council

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SOUTHERN METROPOLITAN REGIONAL COUNCIL

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1. Executive Summary

This report marks the completion of the Compost Market Development Project which was designed to generate interest in and highlight the advantages for commercial farmers of using compost made from Municipal Solid Waste (MSW). This has been the largest farm compost demonstration so far in Australia. Until now MSW compost has not been widely used in farming, although it is low cost organic matter and has potential to greatly improve farm sustainability and productivity. During the course of the project it was identified that additional research was required to examine the viability of the more economical pelletised compost in broad acre farming systems. This addendum will be completed in December 2006.

The project was initiated by the Southern Metropolitan Regional Council (SMRC) and Organic Farming Systems (OFS) and received its financial support from the Western Australian State Government. This was in response to the West Australian Government's objective of guiding the community towards a path of zero waste. It has been estimated there could be 300,000t of MSW based compost produced from the Perth metropolitan waste stream if all the possible compost sites are established, which currently exceeds demand. By showcasing the advantages compost can offer farmers, they will be encouraged to trial it on their own properties, creating a demand for the product.

Compost is a valuable resource offering significant agricultural and environmental benefits to farmers and the community because of its unique characteristics, which can offer significant returns to farmers in the form of increased crop yields and improved quality of produce.

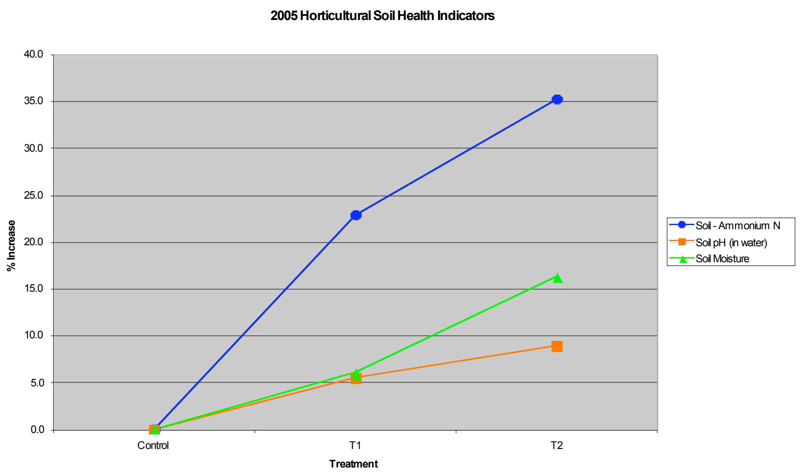
- Compost is full of nutrients and trace elements essential for healthy plant growth. As it breaks down, nutrients are released, providing a "slow release fertiliser" for plants. This reduces the need to use synthetic fertilisers (significant pollutants themselves) by returning valuable nutrients to the soil.
- Compost improves soil structure resulting in increased water holding capacity and nutrient retention of the soil. This reduces the irrigation needs of farms and the potential ground water contamination from synthetic fertilisers.
- Compost improves soil microbial activity, which potentially reduces the incidence of plant root diseases.

Compost provides nutrients in the soil while increasing organic matter, whereas our current farming systems provide nutrients but reduce organic matter leading to soil degradation.

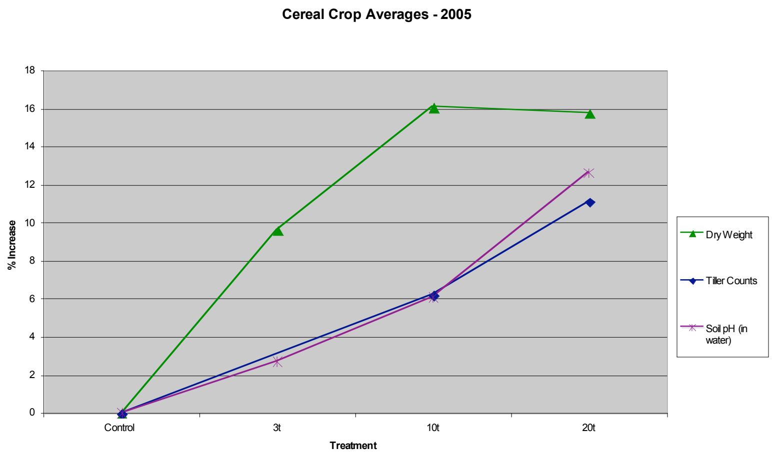
Broad Objective
The aim of this project was to develop a market for MSW compost by demonstrating the benefits of MSW compost in a wide range of farming situations. The objective was to progress farmers from the initial "awareness" phase of market development (most WA farmers were aware of the benefits of compost but had little practical experience), through witnessing the benefits of compost on a farm similar to their own, to being interested in trialling compost themselves and adopting it as a farm input.

46 demonstration sites were chosen, most within a 150km radius of the SMRC facility, with a relatively even spread of broad-acre and horticultural crops across the region. A diverse range of farming types and crops were chosen including wheat, canola, barley, wine grapes, turf, olives, stone-fruit, citrus and avocados. The project was undertaken over two growing seasons, with control (no compost) and compost treatments being set up on each property. Normal fertilising regimes were maintained on both control and compost treated plots. Soil fertility (pH, moisture and nutrients) levels plus indicators of plant growth and/or yield were measured on all plots.

Results
This project demonstrated outstanding improvements in soil fertility and crop yields using MSW compost. Soil fertility consistently improved in the area of soil moisture (up to 20% increase), organic carbon (up to 60% increase), pH (consistently reduced acidity) and soil bacterial ratios (aerobic:anaerobic). On broad-acre farms this was represented in obvious soil moisture improvements in the dry 2004 season, and in horticulture by increased soil moisture and retention of soluble nitrogen in the root zone.



Improved crop performance was highlighted consistently by extra plant growth (up to 33%), higher yields (up to 42%) and in many cases improved quality of produce. In broad-acre crops this was evident in improved plant dry weights, tillering and grain yield. In horticultural crops improved performance was reflected in increased tree and vine growth rates, higher turf production, increased fruit yield and sugar content.



These outstanding results of MSW compost, in improving soil health and crop productivity, have been extended across a large number of agricultural and horticultural producers in Western Australia. 46 participating farmers and approximately 1,000 people have been actively involved in promotional field day activities and presentations, with a further 917 people registering their interest through visiting the website and downloading information on trial results.

Cost benefit analysis of the use of the compost in horticulture showed a positive return in the application to Viticulture, Citrus and Turf farming. However transport costs were a significant barrier to broad acre cereal crop farming. In the second year of this project, this was addressed on a small number of properties by examining ways to reduce the volume of compost used (lower application rates), assessing the residual benefits of compost when it was not reapplied in the second year, and pelletising compost. Positive benefits were gained from compost in all three situations, indicating an obvious need to find cost effective ways to use the compost.

Surveys of farmers participating in the trial showed that 91% had a positive impression of the compost quality, 81% had no problem integrating the compost into their farm management schedule, 85% were prepared to pay freight costs, 86% were prepared to continue to use the compost and 82% would like to trial pelletised compost. Farmers were interested to understand the impact of MSW compost on the soil heavy metal levels. The project showed after two years of compost application, there was no evidence that repeat applications of MSW compost increases the residual heavy metal levels in soil.

The Report found that the market potential for the use of MSW compost within a 150 km radius of Perth was 2.5 million tonnes for broad acre farming and 630,000 tonnes per year for horticulture. Considering the supply from proposed MSW facilities is 300,000t, there will be considerably more demand than supply in the future. The input cost of compost (with freight costs being a considerable component) will be the biggest hindrance to farmer use. Farmers will need specialised advice integrating compost into their farming practices by reducing other inputs costs.

Implications/Recommendations
Government foresight and financial support has enabled the SMRC and OFS to successfully complete the initial stages of market development for MSW compost with this Demonstration Project. With continued funding we can support the following recommendations.

To encourage more widespread use of compost within the farming community we recommend:

1. Encouraging farmers to integrate compost into their farm management practices. This can be achieved by carefully reducing synthetic fertiliser inputs with expert advice.
2. Continuing to promote the results of this project amongst the farming community by seeking support to present the report's findings at future conferences, farmer field days and workshops.
3. Training of agricultural consultants in the benefit and usage of compost systems
4. Exploring the viability of freight subsidies, economies of scale and innovative logistics solutions as farmers believe freight costs are the largest constraint on the use of compost.
5. Exploring methods to reduce application rates by precision placement of compost; eg sub-soil banding in trees and vines.
6. Further monitoring of existing trial plots for 1-3 years to assess the ongoing residual benefit gained from using compost. This will refine the cost-benefit analysis to underpin the economic viability of using MSW compost.
7. Concentrating bulk compost marketing on the horticultural sector, which has shorter freight distances, higher value crops.
8. Establishing trials to examine the effectiveness of MSW compost in ameliorating saline agricultural land.
9. Reducing the chemical and physical contaminant levels in MSW compost via engineering solutions in manufacturing facilities, education of waste generators and source separation of waste.

Further trials examining the response of broad-acre crops to pelleted compost will be completed in December 2006.

2. Background

There are large quantities of organic waste produced each year in Western Australia and disposing of waste to landfill has become more environmentally sensitive and costly. The Western Australian Government provides strategic direction for waste management via the WA Department of Environment and the Waste Management Board. In its Statement of Strategic Direction for Waste Management in Western Australia the department has committed to ensuring "all Western Australians will live in a waste-free environment" (Dept of Environment, 2004).

As we do not currently live in a waste free society the Waste Management Board has developed three principals to guide the community along the path towards zero waste.
These principals are:

- Prevention of waste creation
- Recovery through recycling or re-processing
- Disposal of waste responsibly

(Dept of Environment, 2004)

Compost production from municipal solid waste (MSW) and its use in agriculture will contribute significantly to the second principal of recovery.

The SMRC's Regional Resource Recovery Centre is the first of several (potential) MSW compost sites (see Photo 1) to be commissioned around Perth and it commenced production of compost from early April '03. At full production the facility produces approximately 100 tonnes of compost per day or 500 tonnes per week.

Photo 1: SMRC Waste Compost Facility

It has been estimated that there could be 300,000t of MSW based compost produced from the Perth metropolitan waste stream if all the possible compost sites are established. The large quantity of compost potentially produced by these facilities (the SMRC facility is only 10% of total) far outstrips the ability of the current domestic market to absorb (~100,000t, excluding soil mixes and mulches) and as a result there is a need to carefully develop the fledgling agricultural compost market.

This Farm Compost Demonstration was established by the Southern Metropolitan Regional Council (SMRC) and sponsored by the State Government through its Waste Management Board as a means of generating interest in, and developing a market for MSW compost in commercial farming.

The techniques for producing good quality compost for use in agriculture are well understood and have been practiced in WA for a number of years. The compost industry is well aware of how to use these products (rates, timing, etc) in a range of different types of agriculture. The use of MSW compost however, has not been tried in WA, and there are questions within the community about whether municipal waste can be made into compost that is both safe and useful.

Today, most agricultural businesses in Western Australia are using synthetic fertilisers to feed nutrients into their crops. Compost, which is also a source of nutrients, is currently not used widely, even though it offers the potential for long term solutions to soil management, something synthetic fertilisers alone are unable to achieve.

The benefits for farmers from using compost include improved soil moisture, nutrient retention and buffering capacity. Improved soil moisture retention can increase yields in broad-acre crops and improve water use efficiency in irrigated crops. Retention of more nutrients provides better use of fertilisers resulting in reduced leaching and improved buffering capacity, allowing for healthier soils that are more resistant to acidification.

Relatively small quantities of compost can significantly increase soil organic matter (carbon) levels. For example, if 12.5t of compost is applied to a hectare of soil that has 1% organic carbon, then the soils' organic carbon content will increase by around 25%. Many of WA soils contain less than 1% organic carbon.

Large scale adoption of compost on farms has significant benefits for the community. Compost has the ability to retain nutrients which means less nutrients flow into groundwater, streams and rivers resulting in less pollution of our water ways. Compost's ability to "hold" moisture means less water is needed for plant growth. Given the growing water shortage in our community, reducing the water needs of farmers by using compost is important. So by recycling waste into compost, and using this on farms, we are not only solving landfill issues, but reducing a major pollutant to our water ways and addressing water shortage problems.

Prior to this project, the primary inhibitors to the development of compost usage by farmers were the cost of compost and uncertainty of its effectiveness on individual farms. The current cost of commercially produced compost is $35-41/m^3$ plus transport, which for a farm that is 100 km from the production site would cost in the order of $41-46/m^3$. At recommended application rates the cost is about $200-230/ha for cereal farmers and $410-1,380/ha for horticultural enterprises, plus application costs. As such farmers are reluctant to invest in compost until they can see a demonstrated benefit.

Given the benefits of compost to both the individual farmer and the community, the challenge is to find ways to encourage farmers to use compost, see the advantages, and then help them find cost effective ways to make compost an integral part of their farming practice. So, as with all new products, significant market development needs to occur.

A proven market development technique in agriculture is this four-step process that has the objective of gaining:

1. Farmer awareness
2. Farmer Interest
3. Trial on their farm, and
4. Adoption as a farm input/practice

Market development of this type is a protracted process and can take many years.

Research conducted by the Compost Industry Working Group using funds from the Waste Reduction and Recycling Grants Program showed that farmers are aware of compost and its benefits, step 1 on this market development continuum. As with all new products, farmers have many questions about compost which delays decision making, such as; "Is it expensive?", "Will it work on my farm?", and "How do I apply compost?". The need then is to move to steps 2 & 3, gaining farmer interest and trialling compost on farms, to demonstrate the benefits.

This project is aimed at steps 2, 3 and 4 in this market development continuum, trialling compost on a large variety of farms to show farmers its benefits, as well as to show them compost produced from municipal solid waste is cost-effective. Farmers generally believe compost is beneficial but are unfamiliar with how to best use it and believe the cost is generally too high. With compost having so many advantages not only for farmers but the community at large, this project is an important step in moving farmers towards more sustainable farming practices. The State Government has understood the significance of this, by providing funding of $800,000, which makes this the largest compost demonstration project to be undertaken in Australia.

3. Objectives

The aim of this project is to develop the compost market by demonstrating to farmers the benefits of using MSW compost, while reassuring them of its safety and quality. The objective is to create a demand for compost within the farming industry and increase the adoption of MSW based compost by farmers.

To achieve this objective the project aimed to do the following:

- Choose a representative group of farms within a reasonable distance of the SMRC facility so farmers would be able to assess the benefits of MSW compost on properties similar to their own.
- Show MSW compost improves soil health and crop yields compared to control areas where compost was not used.
- Show MSW compost is safe and healthy, ie behaves like regular compost
- Show compost is cost effective. In this study compost is used in addition to the farmer's regular program as the nutrient value of compost was uncertain. Some farms were expected to show the cost effectiveness of compost, but the real cost effectiveness occurs when it is integrated into the farm system.
- Show the results to large numbers of farmers.

4. Processes in initiating and managing the project

Overview

With the overall objective of this project being to demonstrate the benefits of MSW compost on around 50 farm sites over a 2 year growing season, there were a myriad of issues that needed to be addressed in initiating and managing the project. This section outlines those in detail.

To summarise the project was managed in the following ways:

- To ensure adequate discussion and coverage of issues relating to the project a steering committee was established which met at regular intervals.
- The SMRC managed the quality and production of the compost.
- Organic Farming Systems managed the demonstration project.
- A number of criteria were developed to select a representative group of 21 broad-acre and 25 horticulture farms within 150 km from Perth. There was considerable diversity in the farms, ranging from new to mature orchards and vineyards, turf farms, wheat and oil seed crops, sandy and clay soils. This was to ensure the farms chosen would be representative of those within the area and hence relevant to a wide range of farmers. Farmers included were prominent in their area and willing to contribute to the marketing of the compost.
- On each demonstration site, control and treatment plots of ~1ha size were set up. In the first year treatments of 10t and 20t/ha compost were used on each farm. Past experience (Bedbrook 2004, personal communication) has shown this is the minimum amount required to demonstrate improvements in crop growth.
- Normal fertiliser regimes were maintained on both control and trial plots.
- Soil moisture and nutrient levels plus indicators of plant growth (varied according to the crop eg yield, stem width, fruit sugars) were measured on all plots.
- In the second year, some changes were made in the program to further explore results from the first year. These included introducing pelletised compost and a lower, 3t/ha rate in broad-acre crops
- To encourage the broader farming community to see the benefits of compost, demonstration field days were run at the end of the first and second seasons. In addition professionally produced booklets outlining the benefits of compost were sent to the large number of people responding to advertisements or logging onto the website.

4.1 Steering Committee

To ensure adequate discussion and coverage of issues relating to this project a steering committee was established in 2003.

The committee consisted of eight members drawn from a wide range of fields including farming, compost industry, regional councils, Department of Agriculture and the Waste Management Board.

Richard Cooke (Beverley farmer)
Andy Gulliver (Custom Composts)
Bob Paulin (W.A. Department of Agriculture and Food)
Stephen Fitzpatrick (Eastern Metropolitan Regional Council)
Steven David (Organic Farming Systems)
Stuart McAll (Southern Metropolitan Regional Council) - Chairperson
Diane Dowdell (W.A. Waste Management Board) – Adam Parker also represented the WMB at earlier meetings.

Early in the project life the steering committee met on a regular basis with the first meeting in September 2003 and later meetings were on a seasonal basis as the project issues were already established.

4.2 Compost Quality Assurance

Production of compost from MSW requires a rigorous quality control program to ensure compost is fit for use in the target markets. Consequently a comprehensive quality control program has been implemented by the SMRC to ensure the integrity of the compost and help reinforce to customers the product is fit for purpose and meets appropriate standards.

The current standard, Australian Standard AS4454-2003, provides guidelines to ensure the safe use of compost in relation to human health (pathogens), heavy metal levels, pesticide residues and physical contaminants.

The approach taken by the SMRC was to agree on compost standard and develop an appropriate Quality Assurance program to manage the contaminant issues along with a number of characteristics for plant safety.

The SMRC program requires some analyses to be conducted in-house and some by outside laboratories where the capital cost of equipment is prohibitive, staff technical knowledge requirement is too high or the frequency of tests to be conducted is low.

The SMRC Quality Control Program (see Figure 1 below) provides for testing at three critical stages; on inputs, process monitoring (digester and air-floor) and final testing prior to despatch.

Inputs

- Raw materials (other than MSW) – heavy metals, C/N ratio

Process Monitoring

- Digester – Constant monitoring via computer plc of temperature, oxygen/carbon dioxide, moisture.
- Air-floor – Temperature, oxygen/carbon dioxide, moisture, pH.

Final Testing (each batch of screened compost)

- Australian Standard (AS4454-2003) including physical and chemical contaminants; pathogens;
- Tests that are not part of AS4454 – plant nutrient value of compost.

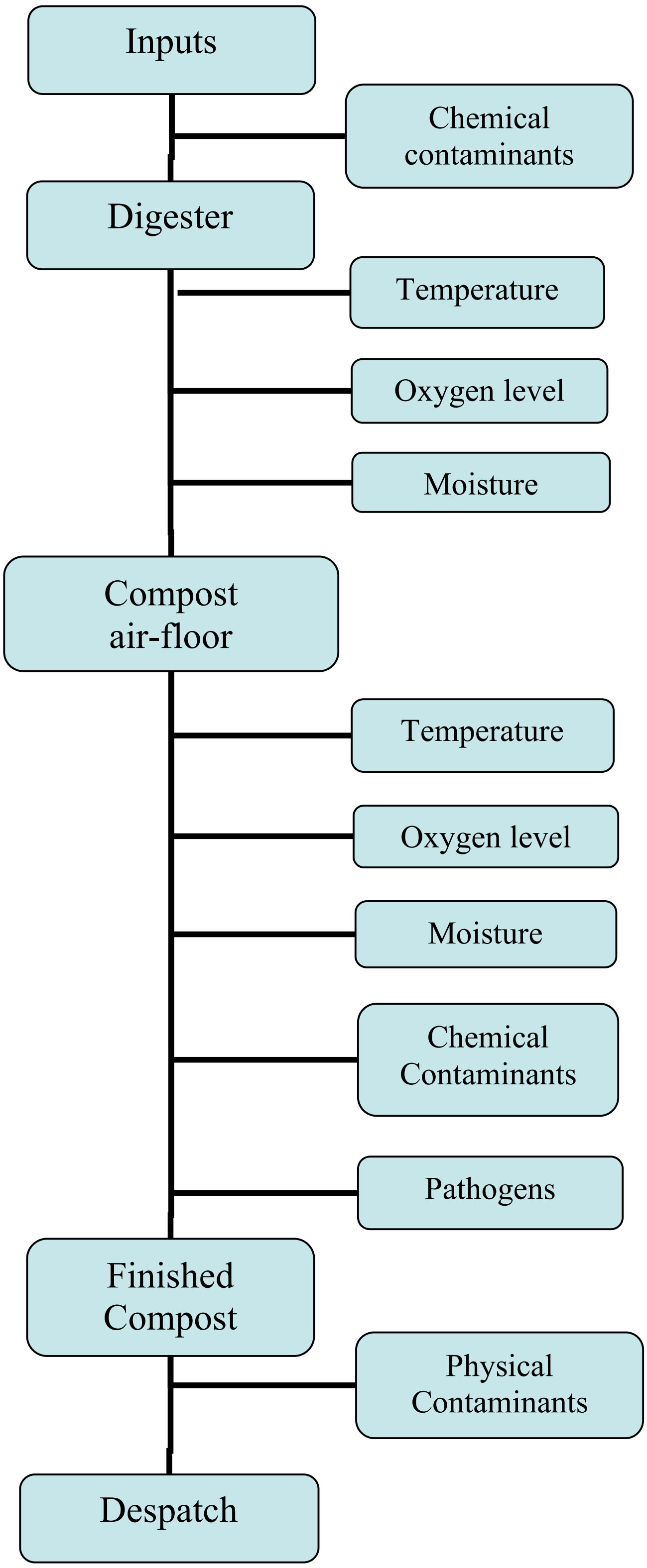
Photo 2 – Process monitoring at the SMRC compost facility

Compost does not physically move from one stage to the next without passing appropriate quality control tests. Compost that does pass the testing is removed from the process to be reworked (eg screened again to remove glass particles) or re-composted in the case of high pathogen counts. All compost can only be moved off site once it has passed all quality control procedures.

Production and compost quality were the responsibility of the SMRC and the Waste Compost Facility production team, including:

Stuart McAll – CEO
Brendan Doherty – Engineer
Dean Lokan - Production Manager
Stephen Roberts – Quality Assurance Officer

Figure 1: Compost processing stages and monitoring (right hand side)



4.3 Project Management

The MSW Compost Demonstration Project was managed by Organic Farming Systems, a consulting firm established in 1995 to focus on sustainable farming practices.

The Organic Farming Systems staff working on this project included Principal Consultant, Steven David and Project Agronomist, Chris King.

Steven David
Steven David is the Principal Consultant for Organic Farming Systems and is highly experienced in agronomic, marketing and agri-business management roles. He graduated from the University of Western Australia in 1980 with a degree in Agricultural Science (HONS), majoring in soil biological science. Steven has over 25years experience in sales and marketing to farmers, including national marketing manager roles in agriculture and consumer goods.

Chris King
Chris King has been the Project Agronomist for the MSW Compost Market Development Project. He graduated from the University of Western Australia in 1994 with a degree in Horticultural Science (HONS). Chris has experience in management of field trials with the WA Department of Agriculture, and soil and crop monitoring with Agrilink International.

4.4 Selection of Farms

Recruiting broad-acre farmers and horticultural growers to participate in the demonstration project commenced in October 2003 with a series of advertisements calling for expressions of interest. These were run over a four week period in the Countryman and Farm Weekly newspapers.

Farmers interested in being involved with the project were invited to contact Organic Farming Systems for further information. They received an information pack including background information and the official expression of interest form which could be filled out and submitted for evaluation.

In conjunction with the press advertisements, contact was initiated with farmer associations, Landcare groups and government organisations.

The Landcare Groups contacted included:

- Hotham Catchment
- Serpentine/Jarrahdale
- Wandering
- Williams
- Chittering
- Avon Catchment Council

Farmer associations contacted included:

- Hills Orchard Improvement Group,
- Swan Valley Wine Industry Association
- Citrus Improvement Group
- Fruit Growers Association of WA
- Peel Region Olive Growers Association
- Margaret River Wine Industry Association
- Moore River Olive Association
- Mooliabeenee Grape Growers Association
- Western Australian No-till Farmers Association
- Western Australian Farmers Federation

Government bodies contacted included:

- Beverley Shire
- Brookton Shire
- Boddington Shire
- Chittering Shire
- Gingin Shire
- Northam Shire
- Serpentine/Jarrahdale Shire
- Swan Shire
- Wandering Shire
- Williams Shire
- York Shire
- Department of Agriculture – Waroona, Northam, South Perth

These groups were provided with information on the project so they could inform their members with the view to recruiting participants. It was essential for the success of the project that farmer groups and associations were involved, as they are held in high regard by farmers, and could offer considerable assistance and credibility to the project.

Where gaps existed in location of farms or crops grown a direct approach was made particularly if it was considered these extra farmers would be a valuable addition to the demonstration program.

4.4.1 Information packages for farmers

Given the source of the compost, it was considered important to provide potential participants with professionally produced and printed material that clearly explained the reasons for the project. A specific design theme was developed and used for the duration of the project.

All farmers who responded to the initial advertisements received an "Expression of Interest" (EOI) information pack (Photo 3) that was emailed, faxed or posted, with an emphasis on electronic means.

The pack was designed to provide the grower with the necessary information to make an informed decision on whether to proceed further with their application whilst providing the project managers with the necessary details on the individual farms. The main focus of the information provided was to drive home the message that using compost in an agricultural or horticultural operation had the ability to increase soil organic matter, increase the efficiency of fertiliser use and assist the soil in retaining moisture. The main problems facing WA producers today are low soil organic matter, the increasing cost of fertiliser inputs and reductions in average rainfall and water availability. By targeting these problems and explaining how additions of compost would help alleviate these problems, it was hoped growers' interest would be sparked, and even if they weren't included in the project they would be interested in the results.

The EOI information packs comprised three pages; an outline of the Compost Demonstration Project covering how the trials would operate, why they were being conducted and who was producing the compost and managing the project; a Compost Fact Sheet about compost and its uses; and an expression of interest (EOI) form. The EOI form was designed so it would not be onerous for the grower to complete, but would provide sufficient information about the farmer's property in terms of location, farm type and capabilities. The form was completed by interested farmers and faxed back for evaluation.

Photo 3 - EOI Information Pack

When farmers were accepted into the project they were sent a folder including a welcome letter, information booklet (Photo 4) and trial protocol relevant for each farm.

Photo 4 - SMRC Compost Information Booklet

4.4.2 Selection criteria

Farmers provided the following details on the EOI form:
a) Contact details (phone, fax, email, mobile, farm address)
b) Farm type / crops grown
c) Soil types present on property
d) Total area farmed
e) Number of trees/vines (if appropriate)
f) Closest town to property and distance from town
g) Road-train/semi trailer access to the property
h) Access to a compost spreader capable of handling large quantities of material
i) Current use of compost
j) Willingness to run SMRC open days on their property

These details were chosen so an overview of farm suitability and capabilities could be gained. 79 farmers submitted expressions of interest prior to the deadline. For an application to be considered further, the farm/farmer needed to meet certain criteria set by the Steering Committee:

- The crop grown should be one commonly found in WA
- Soil to be representative of soil types found in the region and uniform over the proposed trial area.
- Area farmed to be sufficiently large to represent a typical commercial operation
- The property to be within a specified distance from the SMRC facility to keep freight costs under control
- Road train/semi trailer access to the property was important to allow delivery of large quantities of compost

- The applicant had to own or have access to a machine which was capable of spreading large quantities of compost.
- To ensure the project was expanding the market, the applicant could not be currently using compost from another supplier.
- The applicant had to be willing to allow the SMRC to run open days on the property for promotional purposes
- Ability to commit to a two year program

Along with the need for properties to fit the above selection criteria in terms of the practicalities of conducting a trial, it was also necessary to ensure that the participant would contribute in other terms.

Would the participant be able to assist in market development of the compost?

Were they a respected member of their local community?

Could it be reasonably certain the participant would devote the necessary time and energy in maintaining the trial site to ensure the best possible chance of success?

To satisfy these questions it was necessary to sort through all the questionnaires received and select the applicants who fulfilled the practical selection criteria. Contact was then initiated to schedule visits to all farms, discuss these issues and to assess specific trial sites.

The objective was to conduct up to 50 trials split as evenly as possible between broad-acre and horticultural operations across the three zones' growing regions (northern, southern and eastern – see Figure 2).

A range of crop types, geographical locations and crop ages (horticulture) were important. Where possible, in the broad-acre sites, wheat, barley, oats and canola were represented and in the horticultural sites, wine and table grapes, stone-fruit, apples, citrus, turf grass and olives were represented in each zone.

Figure 2: Demonstration project trial zones (100km)

4.4.3 Visiting the applicants

Broad-acre
Through necessity, broad-acre farm visits were scheduled first as there was a need to select and establish trial sites well before the autumn break of the 2004 season.

Contact was initiated with the selected applicants and a farm visit scheduled to discuss the issues involved in conducting a demonstration trial on the specific farm. These visits were started in November 2003 and continued through to late April 2004.

The initial farm visit consisted of meeting with the farmer at their property and discussing the aims of the project, the specific trial site requirements and providing them with a sample of the compost so they could see the product and discuss any concerns they had. The applicant would then be asked to suggest potential trial sites they thought would be of interest and then specific paddocks were visited to assess the suitability of a crop or location.

No commitment was given to the farmer at this stage as all farm visits were completed before deciding on the mix of participants.

A provisional list of successful applicants was drafted and submitted to the Steering Committee for final approval.

Horticulture
The initial horticultural property visits took place during winter 2004 so site selections could be made, trial sites established and compost delivered and spread before spring. The meetings with the grower followed the same format as the broad-acre visits, but care was taken to gather information on crop growth stages, irrigation management, truck access, management techniques and farm sampling/harvesting times because of the diverse range of horticultural crops under consideration for the project. The horticulture trial sites are inherently smaller and more intensive than broad-acre sites.

4.5 Demonstration site operations

4.5.1 Site Establishment

All the Compost Demonstration Project trial sites were established and sampled according to accepted scientific soil sampling practices. As this was a demonstration project with large trial sites and a large number of farms, trial plots were not replicated.

A total of 46 trial sites were established. 21 sites were on broad-acre farms and 25 sites were on horticultural properties. At the onset of the project, attempts were made to confine all properties to within a 150km radius of Perth. Some properties outside this range were included due to the lack of suitable sites within this limit.

Figure 3: Trial site distribution around Perth (Black dots)

Every effort was made to choose a trial site which had a uniform soil type across the entire area. This was essential to ensure any differences observed between treated areas were due to the compost applied and not underlying soil characteristics. In most cases this was possible but on some farms this proved more difficult.

All plots (treatments and controls) were sampled prior to trial establishment to quantify any physical or chemical differences and aid in the interpretation of trial results at a later date.

Broad-acre

Broad-acre trial sites were approximately 2.3 hectares in size and established in a paddock that had a uniform soil type over at least this area. The trials consisted of 2 Treatments and one Control with no replications.

Control	No compost (Area = 0.3 hectares)
Treatment 1	10 tonnes compost per hectare (Area = 1 hectare)
Treatment 2	20 tonnes compost per hectare (Area = 1 hectare)

The Control area was designated as the 30 metre wide gap between the two treated areas where compost was spread (the remainder of the paddock could also be considered a control area but samples were collected from the area between the treated areas)

Trial plots were established by measuring distances from existing fence lines or landmarks (roads, trees, water tanks), marked out with survey pegs and coloured tape at each corner and then each of the corner markers were recorded on a hand held GPS unit for further reference.

Photo 5 - All treatments were pegged and logged with GPS

After the trial blocks were established, one composite soil sample was collected from each of the three plots. Each sample was split into two parts, one to be sent to Analytical Reference Laboratory (ARL) for analysis of heavy metal content and pesticide residues and the other was sent to Agric-lab for a nutritional analysis. These initial soil samples (and all subsequent soil and tissue samples) were taken from 5 specific locations within the plot. These were recorded on a GPS unit for future reference, ensuring future sampling always occurred in the same area of the plot.

The heavy metal content and pesticide residue test was necessary to determine if the existing soil complied with Australian Standards (AS4454-2003) and allowed the use of C2 standard compost.

The nutritional analysis was required so that any soil differences between areas marked out for treatments and the control could be quantified. This step is crucial when interpreting results and to determine the effect of compost additions on soil fertility, particularly soil organic matter levels.

After the site had been established, compost was delivered to the farm and the farmer spread the compost during their pre-sowing schedule.

The farmer was supplied with a site map outlining the trial areas and the amounts of compost to be applied to each area. Initial compost deliveries took place during April and

May 2004. Most sites were visited during compost spreading to ensure it was being applied correctly and to accurately record the application rates.

Farmers used either their own existing fertiliser spreading machinery (Multi-spreaders) or local contractors to spread the compost. In all cases after spreading compost, farmers managed the paddock as per their normal practices, including fertiliser.

Photo 6 - Compost application before seeding cereal crop

Photo 7 - Compost spread – Control left and 20t/ha to right of peg

Horticulture

The horticultural demonstration sites were of varying sizes and layouts. Horticultural properties are set up in blocks and rows which vary significantly from crop to crop and property to property.

To ensure differences seen during the trial could be attributed to the compost treatment, it was necessary to find a block of trees, vines or turf that were situated on a uniform soil type, of the same variety and age and on the same irrigation management station.

It was decided that on the horticultural properties the compost would be banded (approximately 0.5 metres wide) down the tree or vine line in the irrigation zone to maximise effectiveness. The horticultural demonstrations were designed to test two different thicknesses of compost against a control treatment of no compost. The treatments are outlined below (no replicates):

Control	No compost applied
Treatment 1	25mm thick compost
Treatment 2	50mm thick compost

Where possible the demonstration site was established as 9 rows of trees or vines; 3 rows for a control, 3 rows for the 25mm treatment and 3 rows for the 50mm treatment.

A specific row was selected from which all soil and tissue samples were collected. This was normally the middle row of each of the treatments, providing a buffer row either side of the monitored row.

If the demonstration site had less than 9 rows the trials were established along the rows. For example, if the block only had 4 rows of vines or trees the site was set up as follows:

1) Measure the total row length and mark the midpoint of each row with orange and green survey tape (this would mark the centre of the control region)

2) Measure 10% of the row length on either side of the midpoint and mark with orange and green survey tape. This provided a control region 20% of the row length in the midpoint of the row.

3) One end of the rows outside the control are marked with green survey tape and designated as Treatment 2.

4) The other end portion of the rows outside the control are marked with orange survey tape and designated as Treatment 1.

After the site was marked out, 15 trees or vines per monitored row were selected and tagged so all sampling could be carried out on the same trees/vines within a treatment.

In the Horticultural Program, as with the broad-acre program, one composite soil sample was collected from each of the three plots at site establishment. Each sample was split into two, one sample sent to ARL for analysis of heavy metal content and pesticide residues and the other to Agric-lab for a nutritional analysis.

After the site had been established compost was delivered to the farm so spreading could be scheduled into their existing management program. The farmer was supplied with a site map outlining the demonstration areas and the amounts of compost to be applied to each area. The compost deliveries took place during the spring of 2004 and the majority of sites were visited to assist in spreading compost and to ensure it was being applied appropriately.

Farmers either used their own existing spreading machinery (eg Multi-spreader), a compost spreader loaned to the project by Nufab Industries and Custom Composts or local contractors to band the compost down the tree line.

In all cases after spreading compost, farmers managed the paddock as per their normal practices, including fertiliser, cultivation and spraying.

Photo 8 – Broadcasting compost into a vineyard

Photo 9 - Compost banded in vineyard

4.5.2 Record keeping

When a farm was accepted into the program the property was allocated a “site code” so samples and results could be identified with that particular farm and tracked through the system. The site code reflected the type of operation (broad-acre or horticulture), its geographical location (north, south or east), and the order of establishment.

An example of this would be the site codes “BN01” and “HE05”.

“BN01”
B represents a broad-acre site
N represents a site in the northern zone
01 represents broad-acre site number 1 in this zone

“HE05”
H represents a horticultural site
E represents a site is in the eastern zone
05 represents horticultural site number 5 in this zone

A customer relationship management database called “Contact Tracker” was used to keep track of the large number of farmers and the status of the project on each individual farm (Figure 4). The database program allocated all demonstration project participants to a specific section within the database and recorded all inbound and outbound communications, farm visit notes, project milestones and site related activities (eg submission of soil and tissue samples to laboratories) against that demonstration site. Information gathered from any trial site during a particular day was entered into the database at the end of that day.

The program allowed the project team to independently enter information against a site and at a scheduled interval (usually once a week) synchronise the database on the main computer server over the internet so that each member possessed a complete record of all activities against a site.

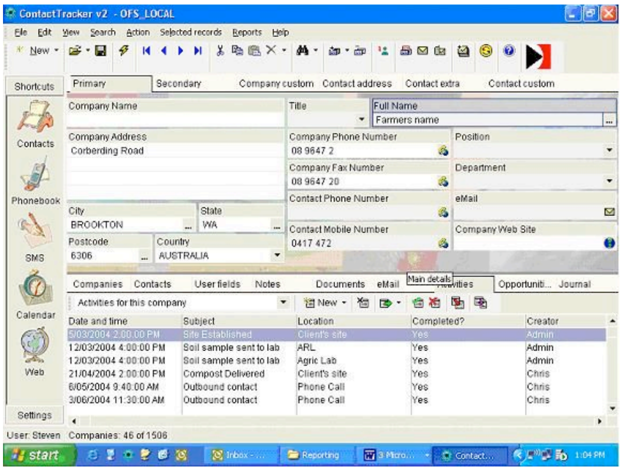
The aim of establishing the database was to ensure all members of the project team had access to the latest information concerning a trial site and that all demonstration project information was stored in a safe and easily accessible location.

All soil and tissue samples collected over the course of the project that were submitted to laboratories for analysis were electronically recorded in an electronic spreadsheet with the corresponding analysis requests. This allowed sample submission dates to be recorded and tracked to ensure all results were received and invoiced appropriately.

It was also necessary to develop electronic spreadsheets which outlined the sampling schedules for each trial site with a corresponding feature that allowed the recording of work that had been completed on each site.

The large number of trial sites undertaken, and the large amount of data that each site generated, made it critically important to maintain extensive and accurate electronic records of all trial activities and results from the onset of the project.

Figure 4 - Contact Tracker database



4.5.3 Broad-acre Crop Management

To maximize the project's market development potential, sites were established for each of the major crops grown in WA. In broad-acre areas this included wheat, canola, barley, oats, hay, lupins and pasture (2004 only).

The crops grown in broad-acre program by geographic location were as follows:

Broad-acre East

BE01	Beverley/Brookton	- Oaten hay
BE03	Northam	- Wheat
BE04	Beverley/Brookton	- Pasture
BE05	Beverley/Brookton	- Wheat
BE06	York	- Canola
BE07	York	- Wheat
BE08	Beverley/Brookton	- Wheat
BE09	Beverley	- Lupins
BE10	Northam	- Wheat
BE11	Meckering	- Wheat (WANTFA site)

Broad-acre South

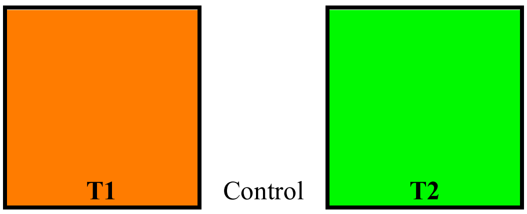
BS01	Darkan	- Barley
BS02	Williams	- Barley
BS03	Brookton	- Barley
BS04	Wandering	- Barley
BS05	Wandering	- Pasture
BS06	Pingelly	- Oats
BS07	Waroona	- Pasture

Broad-acre North

BN01	Gingin	- Pasture
BN02	Gingin	- Lupins/Oats
BN03	Bolgart	- Wheat
BN04	Goomalling	- Wheat

The demonstration sites were spread between the regions to ensure, where possible, each farming/crop type was represented.

In 2004, a typical broad-acre demonstration when viewed from above would look like the example below:



Replicated Study

The demonstration sites were established to demonstrate the benefits of compost to a large number of participants throughout the target market regions. In conjunction with this goal, the need to establish a small scale scientifically designed, replicated trial was identified to generate results that could be assessed with more rigorous scientific scrutiny. If results could be replicated on a small scale, it would provide a level of confidence that the results in the broader demonstration project were valid.

A small scale scientifically (randomized block) designed trial with three replicates was conducted at the Western Australian No-Till Farmers Association (WANTFA) facility at Meckering, approximately 150km east of Perth. The site hosts an annual Field Day which is attended by over 500 farmers, consultants and government extension officers along with numerous field walks and associated promotional activities.

This trial consisted of small scale plots in a randomized block design with three replicates and was monitored in accordance with the large scale demonstration project protocols.

Photo 10 – Small scale plots at WANTFA Meckering Trial Site

Timing of Spreading

Prior to seeding crops in autumn there is a large amount of preparation by the farmer and as a result there is a heavy demand on their time during this period. The spreading of compost was a responsibility of the farmer to include in their pre-seeding program. Some farmers spread the compost as soon as possible after delivery, weeks before the crop was sown, whilst others waited until a few days before sowing to spread the compost over the demonstration site.

Spreading the compost as close as possible to seeding minimises the chance of the compost being blown away by strong winds. If spreading the compost early, care should be taken to ensure it is not subjected to wind erosion. Ideally this means the compost would be incorporated (cultivated onto the ground) or applied immediately prior to a rain event so as to ensure the compost is stabilised on the ground.

Sowing machinery and compost incorporation

In most farming operations, compost will be of maximum benefit if it is incorporated into the topsoil. There are two ways in which this can be achieved.

The first method uses discs or harrows prior to seeding to turn over the soil and incorporate the compost. This method will achieve the best incorporation but requires more effort from the farmer as it is an extra task to be completed. Cultivation also has the potential to increase the crops weed burden by bringing weed seeds from the subsoil to the surface where they can germinate.

The second method relies solely on the seeding machinery for incorporation. There is a range of machinery from "full-cut" combine type machines that completely disturb the top soil through to knife-point type machines which sow the seed with minimal disturbance to the soil.

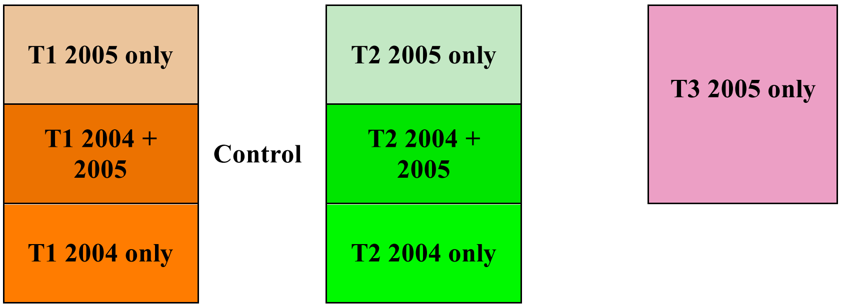
With the "full-cut" type machine the majority of the compost is easily incorporated into the top soil, but with a knife-point type machine only a small percentage of the soil is disturbed and only a small unknown amount of compost is incorporated.

On most farms compost was not incorporated into the soil until the seeding

Changes in 2005

Farmers consider compost to be an expensive input. The Steering Committee decided in a market development project such as this, it was appropriate, given the consistent positive results in 2004, to explore some ways to make compost more cost effective. It was decided to conduct a wider range of compost treatments on fewer properties in the 2005 season. These were the same properties selected during 2004. The aim in 2005 was to demonstrate the residual affect of compost applied in 2004 and compare with single and multiple applications in 2005. There was also a new lower rate of compost (T3 - 3t/ha) included.

Where possible the same area of the chosen paddock was utilised with the demonstration plots moved slightly to create multiple treatments using the same spreading regime as in 2004. Plots were moved so the new 2005 plots would overlap the 2004 plots by 50% (see diagram below) and create a total of seven possible treatments.



One T1 plot received compost in 2004 only
One T2 plot received compost in 2004 only

One T1 plot received compost in 2004 and 2005
One T2 plot received compost in 2004 and 2005

One T1 plot received compost in 2005 only
One T2 plot received compost in 2005 only
One T3 plot received compost in 2005 only

This trial plot layout enabled the project to examine a number of different hypotheses:

> Was there any follow on compost benefit for the next year's crop if compost was not spread again? (2004 only plots)
>
> How did two applications of compost in successive years compare to one application in the first year? (2004 + 2005 plots)
>
> Were the benefits observed from the first application of compost able to be repeated in the following year? (2005 only plots)
>
> Is there a measurable benefit of applying compost at a lower rate of 3t/ha? (2005 only plots)

This modified layout was employed at properties where the trial could be held in the same paddock as the 2004 trial.

If a new paddock was required to conduct the 2005 trial (due to the 2004 site being unavailable) the 2004 layout was replicated in the new paddock.

After reviewing the 2004 trial results it was decided to modify the treatment structure for 2005 depending on the crop being sown. The modifications were crop dependant and additional blocks added only if suitable trial space within the paddock permitted.

The new treatment regimes were as follows:
Wheat: 3t/ha compost, 10t/ha compost plus control
Barley: 3t/ha (if possible), 10t/ha compost, 20t/ha compost plus control
Oats: 3t/ha (if possible), 10t/ha compost, 20t/ha compost plus control
Canola: 3t/ha (if possible), 10t/ha compost, 20t/ha compost plus control

The 3t/ha treatment was included in the trials where paddock space permitted. The rate of 3t/ha represents a one pass spreading event using current spreading technologies (10 and 20t/ha spreading involves multiple passes over the paddock). The lower application rate also allowed the project to closer examine the economic prospects of using compost in a broad-acre situation. The 20t/ha treatment was removed from wheat trials as no significant additional response (over and above 10t/ha) to compost was found in 2004.

The breakdown of the 2005 trial sites by type and geographic location are as follows:

Site Code	**Paddock**	**Crop**	**Trial Layout**	**Treatments (t/ha)**
BE01	Same as 2004	Oats	original	No reapplication
BE03	New paddock	Oats	original	10, 20
BE05	Same as 2004	Barley	modified	3, 10, 20
BE06	Same as 2004	Wheat	modified	3, 10
BE07	Same as 2004	Wheat	modified	3, 10
BE08	New paddock	Canola	original	10, 20
BE09	Same as 2004	Wheat	original	No reapplication
BE10	Same as 2004	Barley	modified	3, 10, 20
BS01	New paddock	Barley	original	10, 20
BS02	New paddock	Barley	original	10, 20
BS03	Same as 2004	Pasture	original	No reapplication
BS04	Same as 2004	Pasture	original	No reapplication
BS06	New paddock	Oats	original	10, 20
BN03	Same as 2004	Canola	modified	3, 10, 20
BN04	New paddock	Wheat	original	3, 10

There were several properties that required the trial site to be moved for the 2005 season. The main reason was the crop rotation system employed by the farmer dictated that the original site was rotating from crop to pasture production. This practice allows the paddock to supply stock feed during the winter, reduce the incidence of crop disease and help control crop weeds in following seasons.

Although compost applications were found to benefit pasture production in 2004, it was decided to focus on cropping performance in 2005 to avoid potential direct consumption of compost by grazing animals.

Two sites were monitored without a second compost application due to the lack of available compost spreading contractors to assist the farmer before seeding.

4.5.4 Horticultural Crop Management

Demonstration trials were conducted in as many of the horticultural crops grown in WA as possible to maximize the market development potential of the project. Where possible demonstration sites were established in both young and old trees and vines; trials on newly established or young crops focused on the growth rates and trials on older plants in full production focused on yield and produce quality.

Horticulture crops included wine grapes, table grapes, olives, pumpkin, citrus, stone-fruit, apples, pears, avocados and turf grass.

The crops grown in the horticultural program by geographic location were as follows:

Horticulture East

HE01	Karragullen	- Apples
HE02	Karragullen	- Stone-fruit
HE04	Beverley / Brookton	- Pumpkins
HE05	Hackett’s Gully	- Stone-fruit
HE06	Karragullen	- Pears
HE08	Wattle Grove	- Turf Grass

Horticulture South

HS01	Harvey	- Wine grapes
HS02	Serpentine	- Citrus
HS04	Dwellingup	- Wine grapes
HS05	Dwellingup	- Stone-fruit
HS07	Jarrahdale	- Stone-fruit
HS08	Jarrahdale	- Stone-fruit
HS09	Serpentine	- Turf Grass
HS11	Serpentine	- Citrus

Horticulture North

HN01	Gingin	- Wine grapes
HN02	Gingin	- Wine grapes

HN03	Gingin	- Citrus
HN04	Gingin	- Table Grapes
HN05	Gingin	- Olives
HN06	Middle Swan	- Wine grapes
HN07	Gingin	- Citrus
HN07b	Gingin	- Citrus
HN09	Gingin	- Turf Grass
HN10	Carabooda	- Avocados
HN11	Swan Valley	- Table grapes

Specific crop management issues for the individual horticultural crops are discussed below.

Wine grapes / Table grapes

A range of properties with both young and old vines were chosen to be part of the project. Trials with young wine and table grapes concentrated on the effect of compost on changes in stem diameter over time (as a measure of vine growth). It was expected that vines in the compost treated areas would experience higher growth rates compared to the non compost treated areas.

Trials in older vines that have already experienced their major growth phases would focus on grape yield and quality characteristics such as bunch weights and sugar contents.

Olives

One olive grove approaching full production was accepted into the project so the emphasis of the trial was to examine the yield and fruit quality (oil % and % moisture content) response of the trees to compost applications.

Pumpkins

Pumpkins are an annual crop so growth stage when the trial was established was not relevant. Compost was incorporated into the seeding line prior to plastic installation and transplanting. The effects of compost applications were measured by yield response and soil fertility.

Citrus

A range of properties with both young and old trees were chosen to be part of the project. Trials with young citrus trees examined the effect of compost on changes in stem diameter over time as a measure of growth. It was expected that trees in the compost treated areas would experience higher growth rates compared to the non compost treated areas.

Trials in older trees that had already experienced their major growth phases would focus on both yield and fruit quality characteristics such as sugar contents and pack-out characteristics (fruit weight and size).

Photo 11 - Healthy citrus tree on Gingin demonstration site

Stone-fruit
A range of properties with both young and old trees were chosen to be part of the project. Trials with young stone-fruit trees examined the effect of compost on changes in stem diameter over time as a measure of growth. It was expected trees in the compost treated areas would experience higher growth rates compared to the non compost treated areas.

Trials in older trees that had already experienced their major growth phases would focus on fruit quality characteristics such as sugar contents and pack-out characteristics (fruit weight and size).

Apples
One apple property was chosen to be part of the project. The trees were mature and in full production so the trial emphasis was on fruit quality characteristics such as average fruit weight and sugar content.

Avocados
One to-be established avocado plantation was included in the project. Compost was delivered and the trial site established before the planting of trees. This provided a unique opportunity to set up a trial which had compost incorporated into the ground before the avocados were transferred from the nursery and planted. Tree growth could be measured via stem thickness changes over time.

Turf grass
Turf grass has the potential to become one of the major users of MSW compost. Turf grass has a short crop life (Perth 2-3 crops per yr, Gingin up to 3 crops per year), is grown all year round and each harvest removes a significant portion of the topsoil which needs to be replaced before the next crop can begin. Three turf grass producers were included in the project, one in each of the Northern, Eastern and Southern regions. To assess the impact of

compost on turf grass production it was decided to focus on measuring root dry weights in each of the treatments. Turf grass is sold at a fixed price per square metre but a bigger, healthier root system allows better establishment of the following crop and a more robust thatch of grass. It was expected additions of compost would result in a higher root dry weight.

The majority of horticultural crops involved in the project are perennial in nature and in fixed locations which meant that for the 2005/2006 season the trials could be re-established by simply re-applying compost to achieve the desired treatment depths, or if the compost was still present in sufficient quantity, monitoring without further applications.

Some trial sites were unavailable for use in 2005/2006 due to change of management staff or the property being sold or redeveloped. New sites on alternative properties were established as per the established protocols to replace these sites in the project.

Photo 12 - Turf grass growing over applied compost

The 2005/2006 horticultural program was as follows:

Site Code	Trial Area	Crop	Treatments
HE01	Same as 2004/2005	Apples	No compost reapplied
HE02	Same as 2004/2005	Stone-fruit	No compost reapplied
HE04	New Block	Pumpkins	5, 10 t/ha incorporated
HE06	Same as 2004/2005	Pears	reapplication to existing levels
HE08	New Block	Turf Grass	60, 120 t/ha
HS01	Same as 2004/2005	Wine Grapes	No compost reapplied
HS04	Same as 2004/2005	Wine Grapes	No compost reapplied
HS05	Same as 2004/2005	Stone-fruit	No compost reapplied
HS07	Same as 2004/2005	Stone-fruit	No compost reapplied
HS08	New Block	Stone-fruit	25, 50mm mulch
HS09	New Block	Turf Grass	20, 40 t/ha incorporated
HS11	New Block	Citrus	10, 20 t/ha broadcast
HS12	New Block	Wine Grapes	25, 50mm mulch
HN01	Same as 2004/2005	Wine Grapes	reapplication to existing levels
HN02	Same as 2004/2005	Wine Grapes	No compost reapplied
HN03	Same as 2004/2005	Citrus	No compost reapplied
HN05	Same as 2004/2005	Olives	No compost reapplied
HN06	Same as 2004/2005	Wine Grapes	No compost reapplied
HN07	Same as 2004/2005	Citrus	reapplication to existing levels
HN07B	Same as 2004/2005	Citrus	No compost reapplied
HN09	New Block	Turf Grass	10, 20 t/ha broadcast
HN10	Same as 2004/2005	Avocados	No compost reapplied
HN11	New Block	Table Grapes	10, 20 t/ha broadcast

4.5.5 Monitoring program

All demonstration sites were monitored extensively throughout the project. Additions of compost into a production system will affect the physical, chemical and biological characteristics of the soil, which leads to an improvement in growth and production capabilities of the crop grown in that soil. To capture and record these benefits, a monitoring program tailored for each of the crop types was designed.

Broad-acre
All broad-acre crops are similar in seasonality and growth response and were therefore sampled at the same growth stages. Table 1 outlines the monitoring and sampling regime followed over the course of the project.

Table 1 - Monitoring program for broad-acre crops

	2004			
	Pre-trial	Mid season (56 DAS)	Flowering	Harvest
Soil HM / PR	x			
Full soil nutrition	x			
Soil Health		x #		
Tissue nutrition		x		
Dry Matter/Tiller counts			x	
Grain yield/quality				x

	2005				
	Pre-trial	Mid season (56 DAS)	Flowering	Harvest	Post-trial
Soil HM / PR	x*				x
Full soil nutrition	x*				x
Soil Health		x			
Tissue nutrition		x			
Dry Matter/Tiller counts			x		
Grain yield/quality				x	

Notes:

x* = conditional sampling. If the 2005 trial was moved to another paddock, a new heavy metal and pesticide residue soil sample was collected to clear the paddock for use. If the new soil was compliant for the use of MSW compost, a full soil nutritional analysis of the new trial blocks was undertaken.

56 DAS = 56 days after sowing.

x # = Selected mid season soil samples in 2004 were chosen for analysis of soil microbiological populations (anaerobic bacteria, anaerobic bacteria, yeasts, moulds, Actinomyces)

Photo 13 - Conducting tiller counts in a cereal crop

Where a trial was located in the same area for two successive years, both the Pre-trial and Post-trial soil samples were analysed for the accumulation of soil organic carbon due to compost additions.

Horticulture

The horticultural crops under consideration differed markedly in terms of rate of growth, growth stage, timing of harvest and physiological activity. A customised monitoring program was developed to ensure each crop type was assessed at appropriate times. Table 2 highlights the monitoring program for horticulture.

Table 2: Horticultural crop monitoring

	2004/2005		
	Pre-trial	Mid season	Harvest
Soil HM / PR	x		
Full soil nutrition	x		
Soil Health		x	
Tissue nutrition		x	
Stem thickness	x		
Fruit yield/quality			x

	2005/2006			
	Pre-trial	Mid season	Harvest	Post-trial
Soil HM / PR	x*			x
Full soil nutrition	x*			x
Soil Health		x		
Tissue nutrition		x		
Stem thickness	x			x
Fruit yield/quality			x	

(x*) Soil heavy metal and pesticide residue levels were assessed before re-application of compost for the 2005/2006 season (if re-application required). Full soil nutrition samples were collected from all trial blocks established during the 2005/2006 growing season.

Tissue nutrition samples were collected in accordance with accepted scientific standards. These standards specify the time of year for samples to be collected for each crop and which part of the plant (leaf and/or petiole) was to be sampled.

Soil heavy metal and pesticide residue content, soil nutrition, soil health and tissue nutrition were all assessed by independent laboratories using samples collected and supplied by the project team.

Stem thickness and fruit yield/quality were assessed *in situ* at appropriate times of the year. Fruit yield was recorded as an average of 15 individual fruit weights collected from monitored rows. Fruit sugar content from each of the 15 fruit samples were recorded and averaged.

4.5.6 Pellet Program

Freight costs are a significant inhibiting factor to compost use in broad-acre crops. As pellets are denser than compost, they can be transported at a significantly reduced rate. Three trials were established during 2005 to examine the response of crops to pelletised MSW compost. These were: one glasshouse pot trial at the University of Western Australia examining the response of wheat plants to various rates of pellets and synthetic fertilisers; one on-farm demonstration trial in late sown wheat in Beverley (re-sown after waterlogging); and one in a summer sorghum crop in Dandaragan.

Glasshouse Pot Trial
A glass house pot trial was conducted to examine the response of wheat to applications of pelletised compost (See Rengel, 2006 in Appendix 11.3). The work was supervised by Professor Zed Rengel at the School of Earth and Geographical Sciences, University of Western Australia. The fully replicated glasshouse pot trial used "Carnamah" wheat and various rates of pelletised compost, one treatment of unpelletised compost and two rates of synthetic fertiliser. The aim was to see which combination provided the best growth and to ascertain whether the compost pellets added to or replaced some of the fertiliser in its capacity to support wheat growth.

The trial was conducted in a climate controlled phytotron which allowed the day length and temperatures to be controlled. Free draining pots containing a uniform virgin brown sandy soil were used. Basal nutrients were added in solution to the soil surface. Compost pellets as well as unpelletised compost were banded approximately 2cm below the soil surface (to mimic the placement of fertiliser in standard agricultural situations) in accordance with the treatment structure.

5 organic fertiliser treatments were imposed:
4 rates of pellets (in kg/ha equivalents: 0,100,200,500)
1 rate of unpelletised compost (3t/ha equivalent)

These treatments were factorially arranged with three rates of inorganic fertiliser (zero, half and full rate) and three replicates in a completely randomised design.

Table 3: Compost pellet trial - treatment matrix

Organic Fertiliser				
0	**Pellets 100 kg/ha**	**Pellets 200 kg/ha**	**Pellets 500 kg/ha**	**Compost 3 t/ha**
No Fertiliser	100 kg + no fertiliser	200 kg + no fertiliser	500 kg + no fertiliser	3 t + no fertiliser
Half Fertiliser	100 kg + half fertiliser	200 kg + half fertiliser	500 kg + half fertiliser	3 t + half fertiliser
Full Fertiliser	100 kg + full fertiliser	200 kg + full fertiliser	500 kg + full fertiliser	3 t + full fertiliser

On Farm Pellet Demonstrations
Two on-farm pelletised-compost demonstration trials were established in 2005. One trial was established in a late sown wheat paddock in Beverley (July 2005) and one in a summer sorghum crop in Dandaragan (September 2005). Each trial was established to examine the effectiveness of pelletised compost to support crop growth in a normal paddock situation.

100kg/ha pellets
Control (no pellets)
200kg/ha pellets

The trial blocks were approximately 200 metres in length with a width equal to that of the seeding machinery used to establish the crop (approximately 8 metres). The compost pellets were to be applied at the time of crop seeding via the seeding machinery so that compost pellets were placed into the soil next to the seed.

The compost pellet rates applied were 100kg/ha and 200kg/ha with the farmer applying the normal inorganic fertiliser regime. After trial establishment the soil and crop monitoring regime followed that of the standard unpelletised compost broad-acre trials.

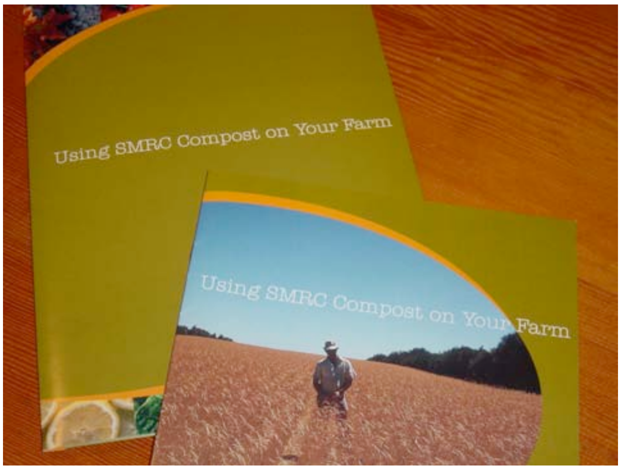
4.6 Information flow

To streamline communications, the intention was to use electronic communications as much as possible. This was the case particularly in the initial stages where large numbers of people were contacted. Once the project was underway mobile phone contact with farmers was expected with emails as a back-up.

4.6.1 Advertising / promotional literature

Prior to expressions of interest a design/image for the project was established that could be used in all visual communications. This tied the various aspects of communication together including advertising, information brochure, folder, website and reports.

Photo 14 & 15 - Project theme was used in all printed material



4.6.2 Public relations

Public relations were a combined effort from the SMRC and the Project Management Team with confirmed coverage of the project launch in newspapers (West Australian, Countryman and Community Newspapers) and Perth TV.

Coverage through the course of the project was gained in The West Australian, Countryman and Community Newspapers. Most significantly ABC TV produced a 10 minute segment on their popular Landline program highlighting the results from both broad-acre and horticultural properties. A copy of the Landline show is included with this report.

Photo 16 - Front page visibility for the Demonstration Project

4.6.3 Web Site

The web site was installed early in 2004 to be used as the main information portal for the project. The page is accessible via the SMRC's home page and the Organic Farming Systems website.

The site has been updated regularly with results and news, including major reviews of results being available via direct download.

Figure 5 - Website was a key communication tool.

4.6.4 Field days/Presentations

Field days, farm walks and presentations were conducted during late 2004 and mid 2005 once sufficient data had been gathered from the demonstration project sites to support the use of compost.

These field days and presentations were critical components of the project to convince farmers of the benefit of compost in a farming system and soil type similar to their own, providing the farmers with confidence to use compost themselves. The format for the field days and walks varied between broad-acre and horticulture with about 900-1,000 farmers and interested parties attending.

Broad-acre

The access to facilities on broad-acre farms encouraged the use of informal field walks. Some of the field days, such as those at Muresk, Meckering and York, were established farmer run events in which we participated. Approximately 600 farmers attended the events over the 2 years, which were held at:

Muresk College Northam (Curtin University) - 2004 and 2005
Beverley – 2004 & 2005
Meckering - 2004
Williams/Darkin – 2004 & 2005
Calingiri/Bolgart – 2004 and 2005
York - 2005

Photo 17 - Farmers attending a field walk at Muresk College – Northam WA

Horticulture
The horticulture field days commenced with a more formal presentations of results (generally in a growers shed) followed by a walk through the crop to discuss specific agronomic issues. These field days were held at:

Gingin – Olives in 2005
Gingin – Citrus in 2005
Dwellingup – Wine grapes in 2005
Waste and Recycle Conference full day tour (2005) of participating farms in Karragullen, Carmel and the Swan Valley.

Lectures/Presentations
Boyup Brook – 2005 (farmer presentation)
UWA Soil Science Lecture - 2005
WA Waste & Recycle Conference – 2005
Landmark Agronomists Conference – 2006
Compost Australia – 2006

Photo 18 - Horticulturists attending a vineyard walk in Dwellingup WA

5. Summary of Results

To develop the market for MSW compost it was necessary to demonstrate the benefits that could be obtained from using this input in a commercial horticultural or agricultural operation. In broad-acre and horticultural crops, the focus was on increasing soil fertility to produce improvements in crop nutritional status and production.

The major soil improvements observed included:

- Increases in pH (from acidic starting points)
- Increases in soil moisture holding capacity
- Reductions in soil temperature
- Improvements in soil microbial balance
- Increasing organic carbon contents

The major crop improvements observed included:

- Increased tissue nutritional content
- Increased plant tillering in cereals
- Increased dry matter production
- Increased grain yield in cereals
- Increased stem growth in young trees/vines
- Increased turf grass root growth
- Increased fruit yield with increased fruit sugar content
- Increased crop growth using compost pellets

One objective of this project was to demonstrate the safety of MSW compost on farms. The farming community is sceptical a safe and useful product can be made from household waste. This project demonstrated both soil fertility and crop production improvements using MSW compost without any demonstrated harm to the environment.

One scientific and fully replicated study was completed to examine whether results on trial sites could be consistently replicated. This was important to provide some confidence in the validity of the broader results. Compost applications in this small trial had a similar effect, suggesting the results in this trial are also valid.

This section summarises the results achieved over the two years of the project in both the horticultural and agricultural sectors. As a large variety of demonstration sites were chosen so a representative sample of farms in each zone could be included, the summary of results (and discussion later) examines trends shown in the data rather than absolute individual results. Anomalous individual results can occur.

5.1 Compost Nutrient Levels

The table below provides the average level of nutrients measured in MSW compost produced during the 2.5 years of the project operations. It highlights that there is a "fertiliser value" of the compost as it contains nutrients that do contribute to crop growth.

Nutrient	Average level in MSW compost	Nutrients applied in 10t of compost per ha
N - %	1.19	89kg
P - %	0.19	14kg
K - %	0.23	17kg
C/N	32	-

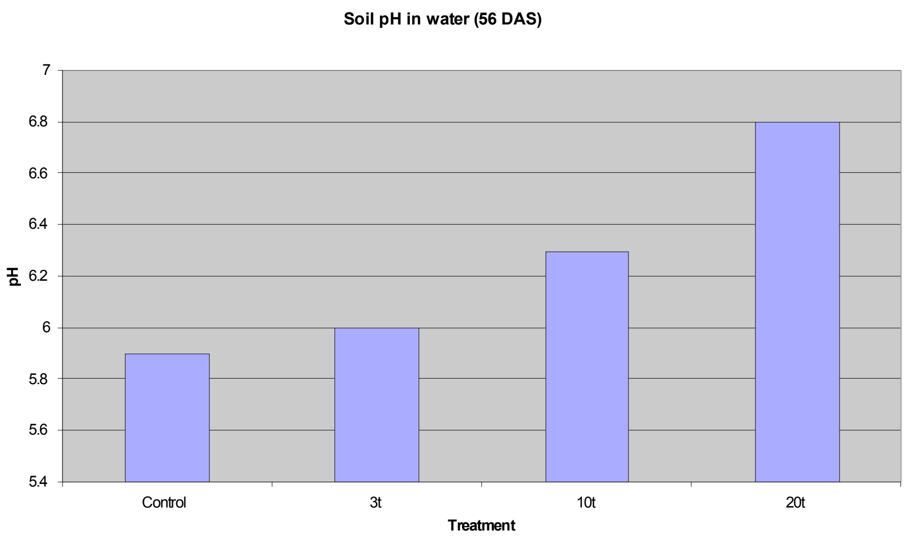
5.2 Broad-acre

5.2.1 Broad-acre 2004

Replicated Study
This trial was conducted to provide replicated back-up data and improved confidence in the unreplicated results from participating farms.

The mid season soil test (56 days after sowing) showed the addition of compost improved pH and increased soil moisture levels. There were no significant changes in soil nitrate, ammonium levels or soil penetrability.

Figure 6 - Soil pH (in water) 56 days after sowing (Average of 3 replicates)



Plant tissue analysis revealed no significant differences across treatments. Plant tiller counts increased with increasing rates of compost application, with an 8.2% rise in tillers per plant at the highest rate of compost (20t/ha equivalent).

Figure 7 - Percentage increase in plant tiller counts 56 days after sowing (Average of 3 replicates)

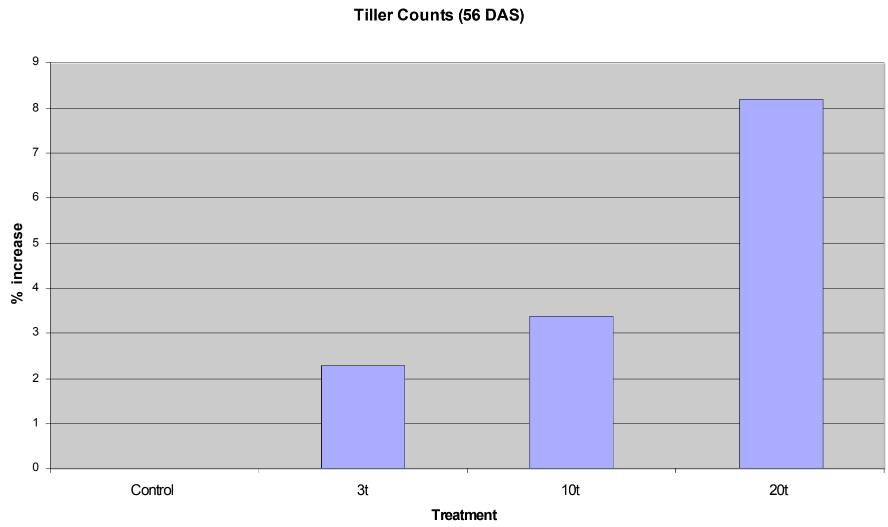
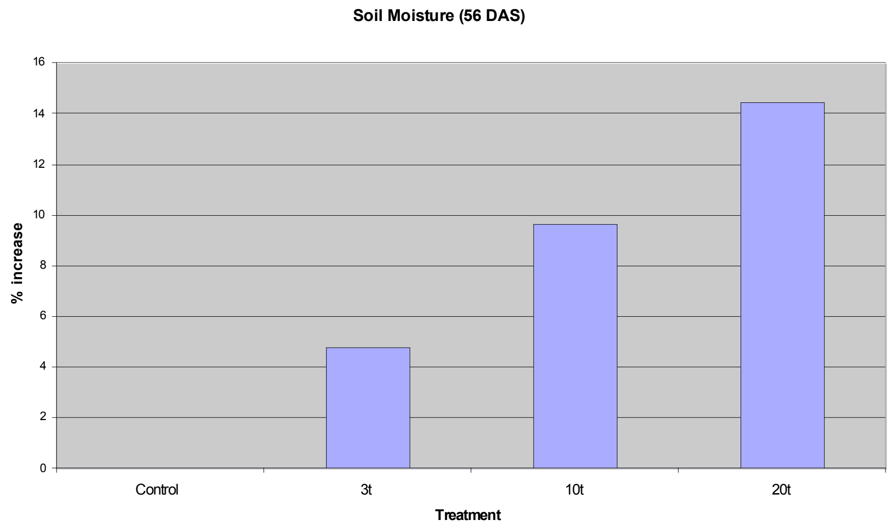


Figure 8 - Soil moisture content 56 days after sowing (Average of 3 replicates).



Harvest results were inconclusive with yield not significantly differing with compost additions (Table 4). This was possibly caused by a combination of low rainfall during the grain filling stage and a severe frost event during flowering. All treatments had low grain numbers per head.

Table 4 - Wheat Yield (t/ha equivalent, Average of 3 replicates)

	Control	3t	10t	20t
t/Ha	3.99	3.80	3.91	3.77
% increase	-	-4.8	-2.0	-5.5

LSD 95% = 0.22

Farm Demonstration Sites

Crops were sown within the farmer's seeding program in autumn 2004 and all treatments received the farmer's normal fertiliser regime.

Inspection of recently emerged crops showed germination of crops was consistent between treatments and there were no adverse affects on crop germination observed at any of the farm sites (see Photo 19 below).

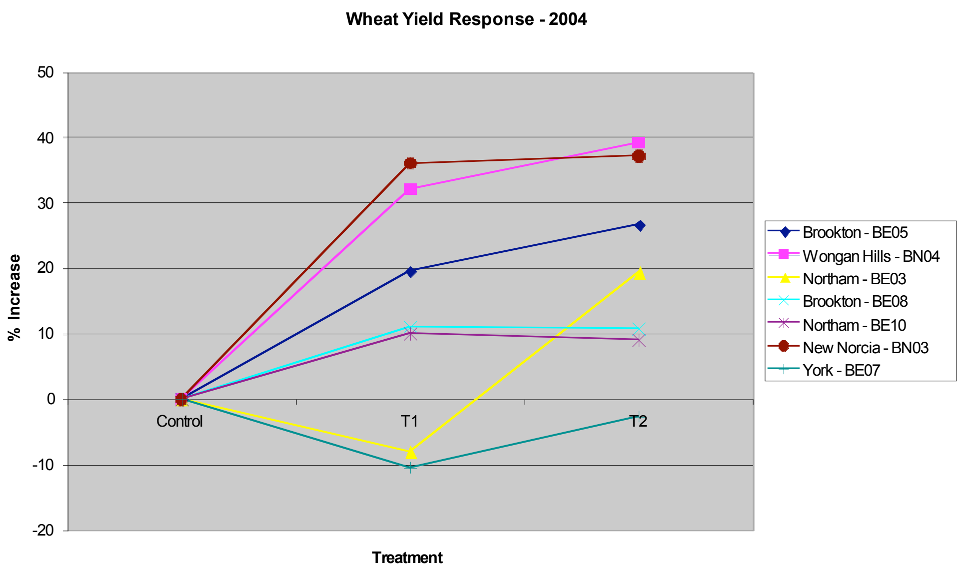
Photo 19 - Wheat plants germinated normally in treated areas
(20t/ha compost treatment at Muresk, 2004)

The results in Figure 9 show average wheat yields increased by 13% in the 10t treatment and 20% in the 20 tonne treatment. On some individual farms, yield increased by up to 39% above the control at the higher rate of compost addition. Figure 9 also shows consistent improvements in soil moisture, plant dry weight and tiller numbers with the application of compost on wheat crops.

Figure 9 - Affect of compost application on wheat production and soil.

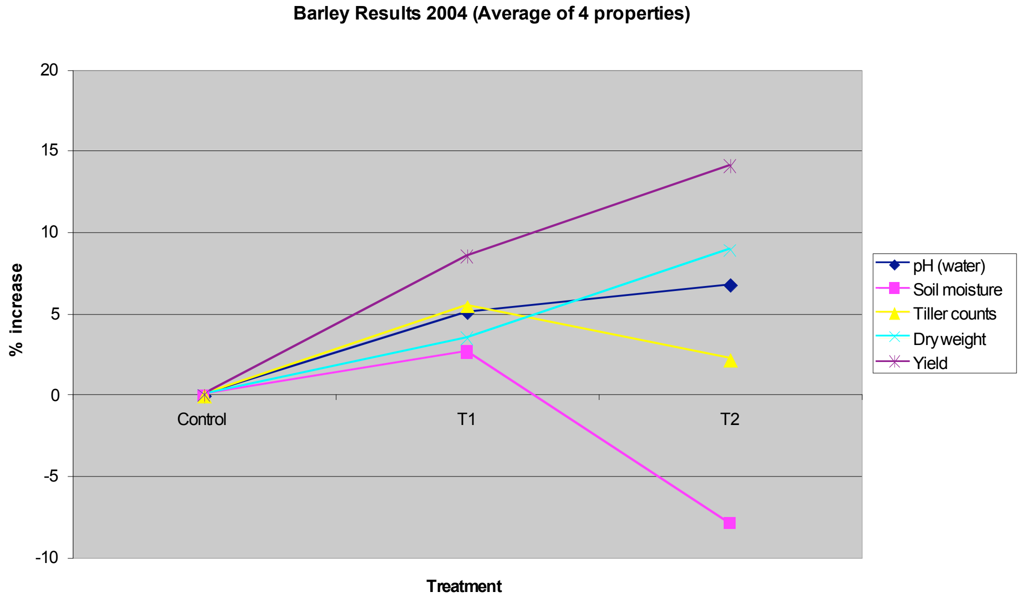
One interesting result observed during the 2004 wheat season (on an individual farm level) was that there was little added benefit of applying 20t/ha compost over and above applying 10t/ha compost (Figure 10) There were no measurable differences in grain quality between the treatments.

Figure 10 - Wheat Yield Response during the 2004 season.



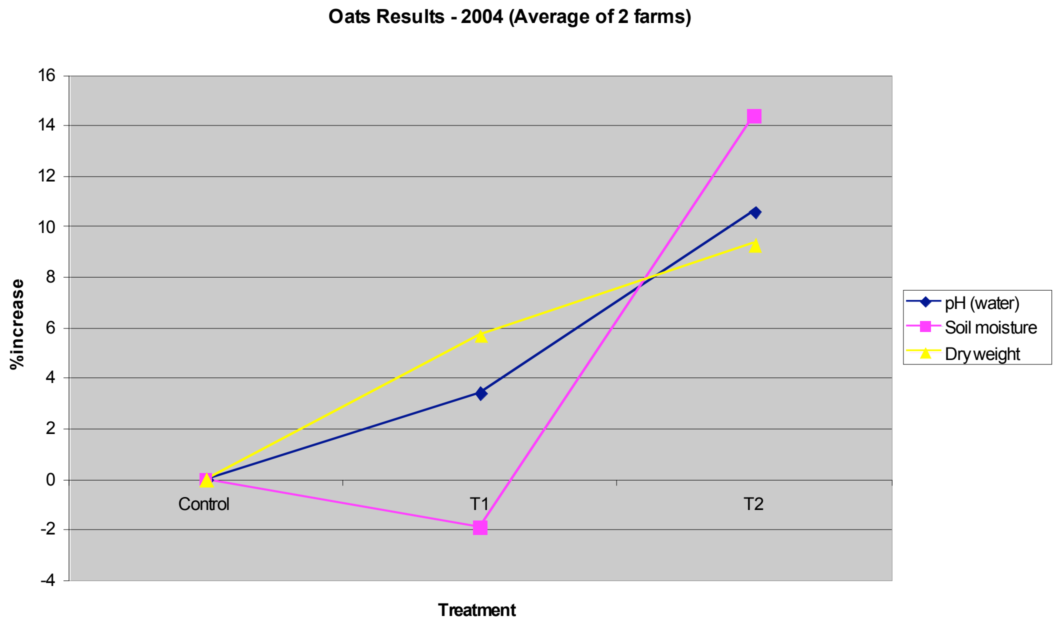
Barley results showed consistent improvements in yield and dry weight with the addition of compost, but less consistency in tillering and soil moisture. (Figure 11).

Figure 11 - Affect of compost application on barley production and soil.



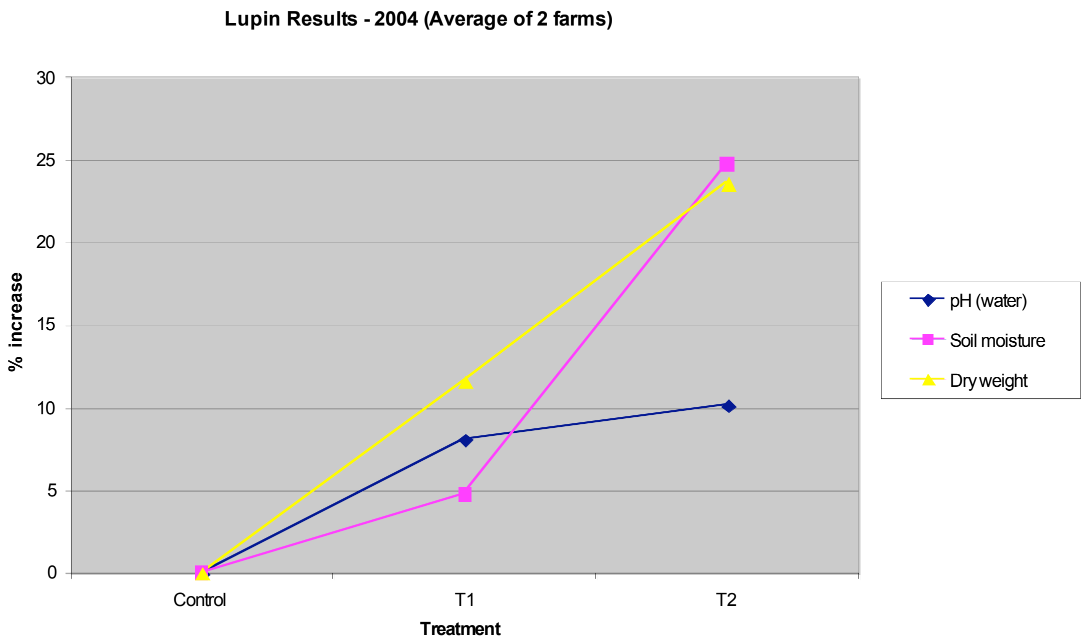
Both oat crops grown in 2004 were cut for hay (no grain yield results). Results in Figure 12 show an approximately 10% increase in dry weight production at the 20t compost rate and similar soil improvements to those achieved in other broad-acre crops.

Figure 12 - Affect of compost application on oat production.



Trial lupin crops grown in 2004 suffered from severe growing conditions. One farm received significantly below average rainfall. The second experienced a severe wind storm after compost application, but before seeding, resulting in considerable erosion of topsoil and compost. Despite this, nearly 25% improvements in lupin growth (dry weight) and soil moisture were measured in the 20t compost rate compared to the control (Figure 13).

Figure 13 - Affect of compost application on lupin production.



Overall, the use of MSW compost on broad-acre farms was shown to improve soils by increasing soil buffering capacity (pH) and moisture retention. The amount of nutrients added to the soil in compost has varied greatly (see Table 5) as some properties received compost batches from early production runs that had relatively low nutrient levels. The farm that used the compost with the lowest nutrient level per hectare also had the highest yield responses. This suggests in 2004 the addition of MSW compost to agricultural soils primarily acted to boost the soils' ability to retain extra water and/or unmeasured microbiological factors.

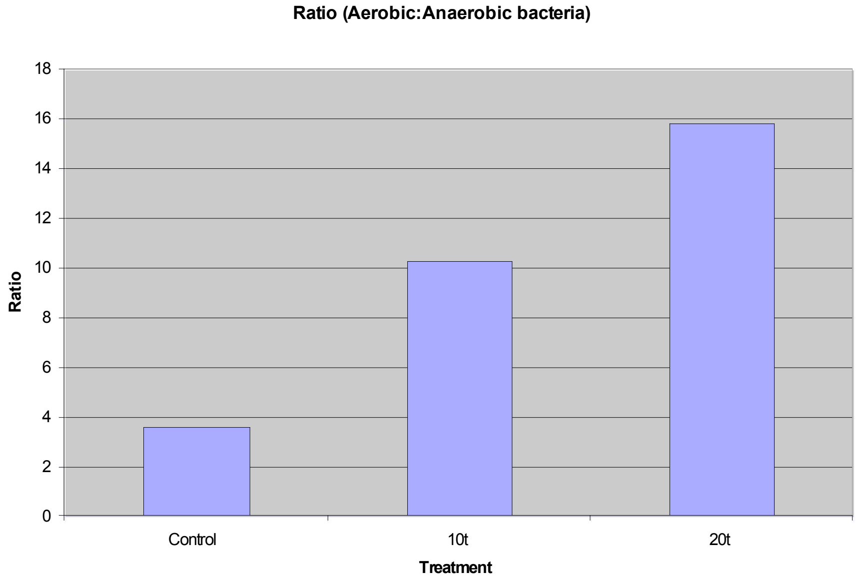
Table 5 - Amount of nutrients applied in compost (T2), by farm (kg/ha).

Property	Nitrogen	Phosphorus	Potassium	Organic Matter
Beverley BE01	181.1	24.4	81.5	3,269
Beverley BE09	184.8	25.2	84.0	3,370
Bolgart BN03	183.9	25.1	83.6	3,353
Brookton BS03	248.4	31.0	83.8	3,726
Brookton BE05	14.8	15.0	43.9	3,900
Brookton BE08	12.8	12.8	35.2	4,896
Darkan BS01	12.8	12.8	35.2	4,896
Gingin BN02	176	20.8	62.4	4,869
Northam BE03	240	30	81	3,596
Northam BE10	204.4	21.9	73.0	4,442
Pingelly BS06	12.8	12.8	35.2	4896
Wandering BS05	245.3	26.3	87.6	5,331
Williams BS02	192.7	22.8	64.8	3,223
Wongan Hills BN04	10.9	10.9	29.9	4,162
York BE07	13.4	13.4	36.8	5,116

Soil Microbiology

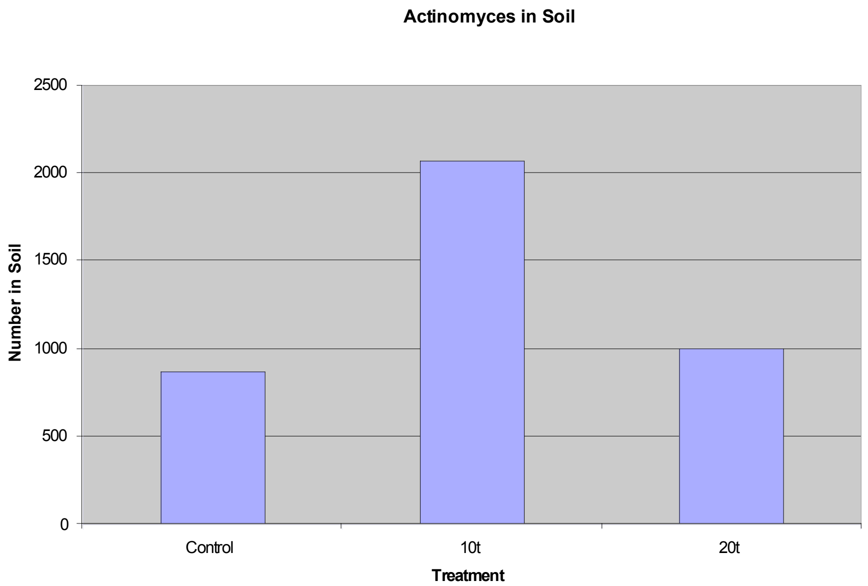
Analysis of the mid season soil samples from 6 randomly selected demonstration trial sites and the fully replicated trial site at WANTFA (collected 56 days after sowing) revealed additions of compost increased the ratio of aerobic to anaerobic bacteria (Figure 14) and increased the number of Actinomyces found in the soil (Figure 15). There were no correlated changes in the numbers of yeast, mould or *Pseudomonas* found in the samples.

Figure 14 - Ratio of aerobic:anaerobic bacteria in mid season soil samples (Average of 6 properties)



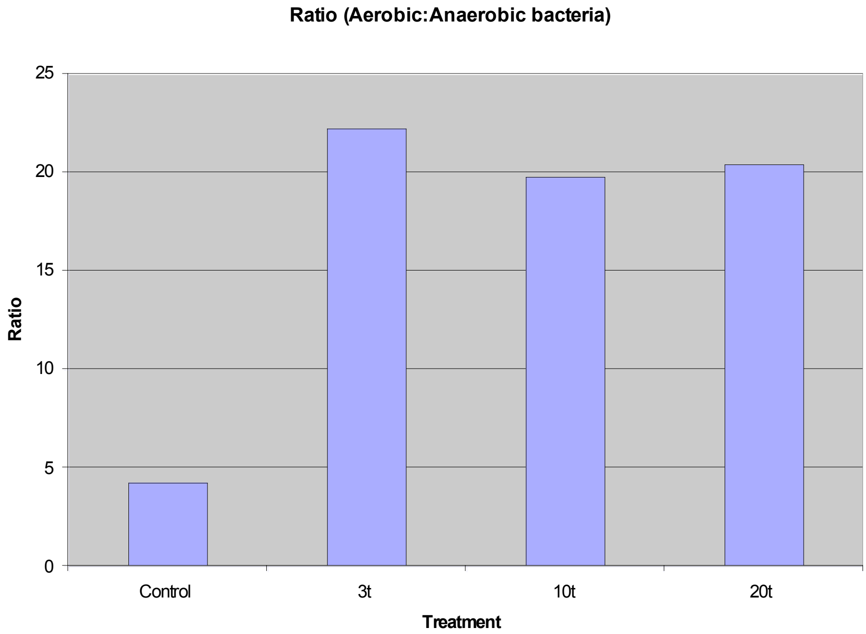
The ratio of aerobic:anaerobic bacteria increased from 3.6 in the control soil samples to 10.2 with 10t compost, and 15.8 with 20t compost (Figure 14).

Figure 15 - Number of Actinomyces found in mid crop soil samples (Average of 6 properties).



The number of Actinomyces found in the mid season soil samples increased from 867 in the control area to 2067 with 10t compost. There were 1000 Actinomyces in the 20t soil samples, lower than the 10t soil but still higher than the control (Figure 15).

Figure 16 - Ratio of aerobic:anaerobic bacteria in WANTFA mid season soil samples (Average of 3 replicates)

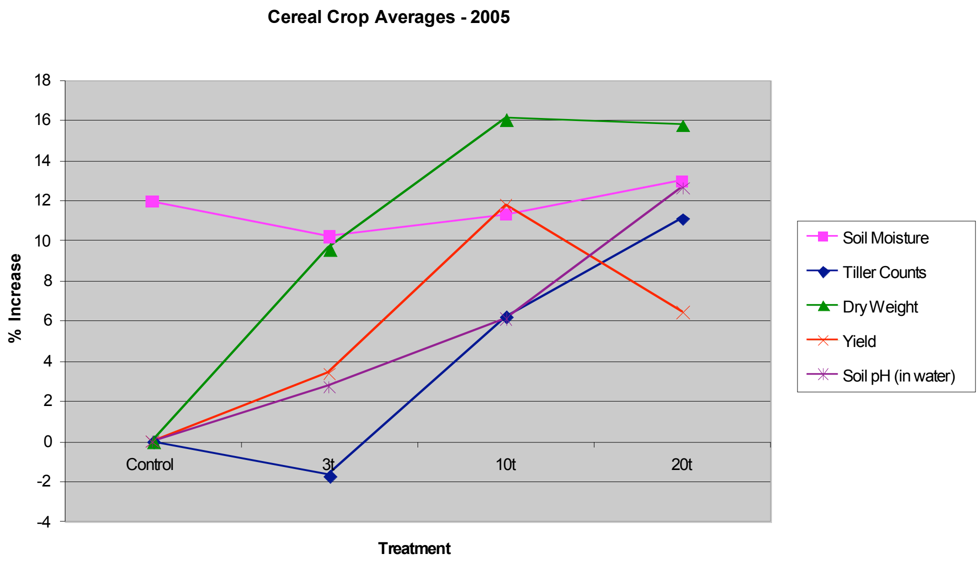


Additions of compost increased the ratio of aerobic:anaerobic bacteria found in the mid season soil samples. The control soil samples averaged a ratio of 4.3 and additions of 3t, 10t and 20t compost per hectare increased this ratio to 22.3, 19.8 and 20.4 respectively (Figure 16).

5.2.2 Broad-acre 2005

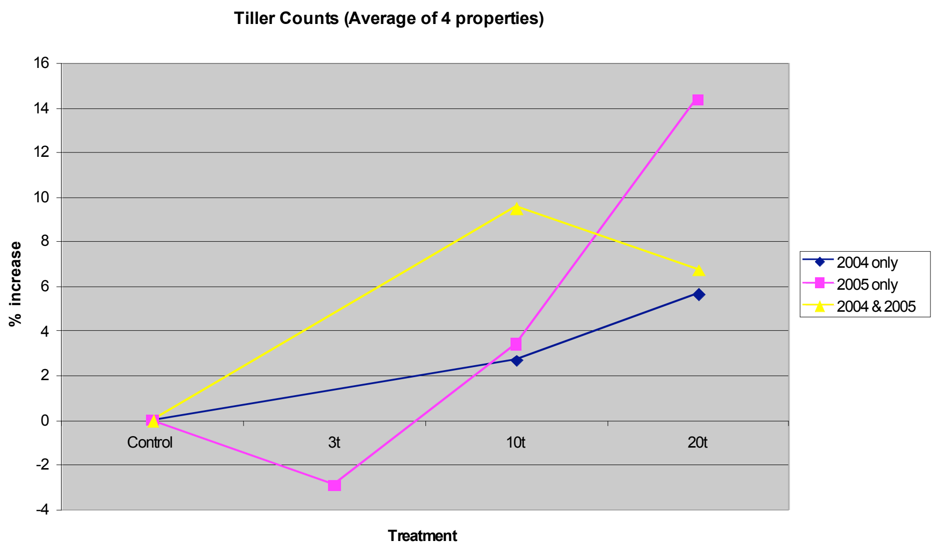
The 2005 broad-acre season results showed the positive compost effects achieved in 2004 were repeatable and that there were significant residual benefits available to the 2005 crop from the 2004 application of compost.

Figure 17 - Soil and crop performance improvements with compost additions



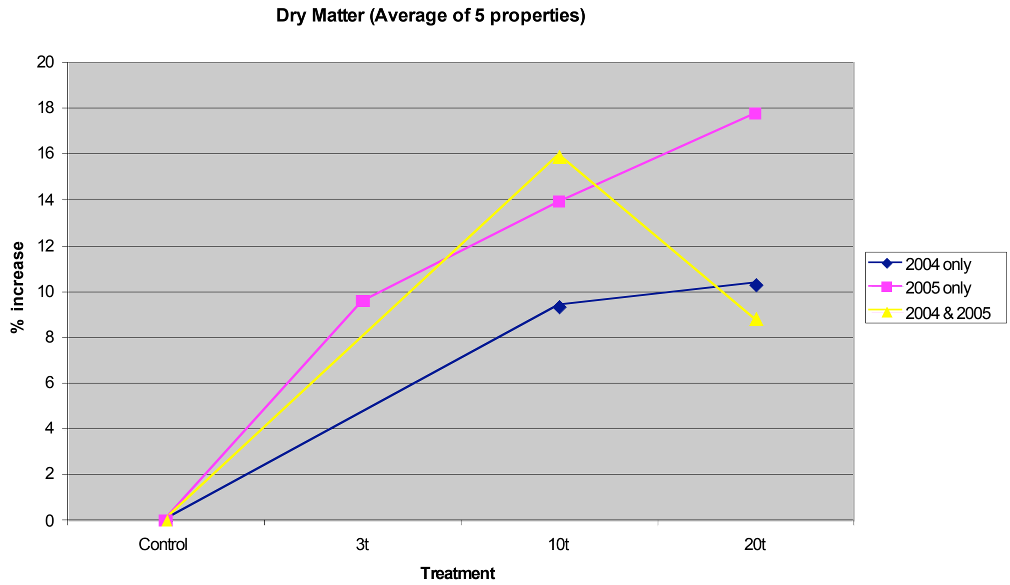
The 2005 season was significantly wetter than 2004 which meant, at the time of sampling, overall soil moisture levels were higher and differences between treatments not as evident. There was an incremental increase in dry matter produced with increasing amounts of compost applied. The 3t compost treatment did not increase plant tiller counts over the control however 10t and 20t compost increased tillering by approximately 6% and 11% respectively. Grain yield increased at 3t and 10t compost applied but was reduced at the 20t rate (Figure 17).

Figure 18 - Residual and current compost benefits for plant tiller counts



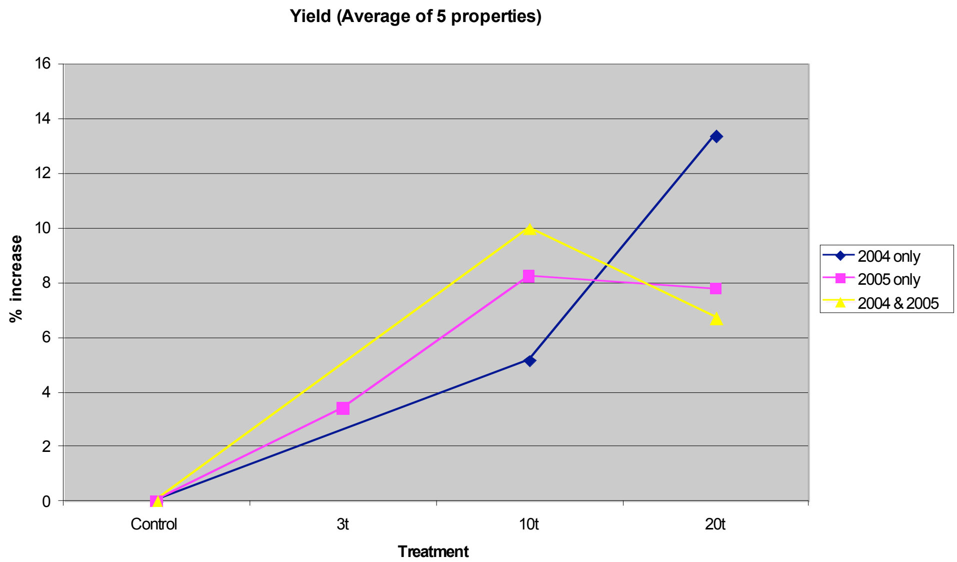
Applications of compost increased plant tiller counts in all treatments except the 3t in 2005. There were residual benefits resulting from the 2004 only compost application with plant tiller counts increasing by 2.7% and 5.6% for the 10t and 20t treatments. Where compost was applied in 2005 only, the number of tillers per plant decreased with 3t compost, but increased by 3.4% and 14% with 10t and 20t compost. Compost application in both years increased tiller counts by 9.5% and 6.7% for the 10t and 20t treatments respectively (Figure 18).

Figure 19 - Residual and current compost benefits for plant dry matter production.



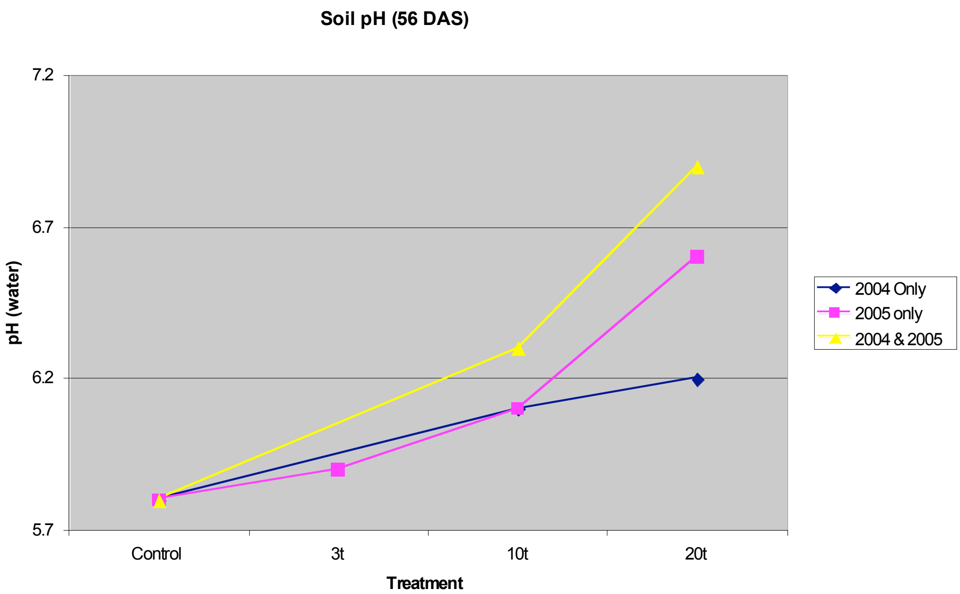
There were strong residual benefits for dry matter production in 2005 when compost was spread in 2004 only. Dry matter increased by 9.3% and 10.3% with 10t and 20t of compost in 2004 only. There was a strong linear improvement in dry matter production up to 17.7% with increasing amounts of compost applied in 2005 only. Plots which received compost in 2004 and 2005 produced more dry matter than the control plots however 10t compost performed better than 20t compost in this case (Figure 19).

Figure 20 - Residual and current compost benefits for crop yield



There was a significant residual 2005 yield response to compost applied in 2004 only. The 10t and 20t treatments improved yield by 5.1% and 13.3% respectively in 2005. Plots which received compost in 2005 only exhibited an almost linear yield improvement above the control however the 20t treatment did not perform any better than the 10t treatment. Plots which received compost in both 2004 and 2005 yielded better than the control plots but the 10t treatment outperformed the 20t treatment (Figure 20).

Figure 21 - Residual and current compost benefits for soil pH



There were significant residual benefits in soil pH in 2005 resulting from the 2004 compost applications. With 10t and 20t compost spread in 2004 only there was a 6.5% and 13.5% improvement (increase) in soil pH during the 2005 sampling period. When 3t, 10t and 20t compost was spread on plots that did not receive compost in 2004 (ie 2005 only) there was an improvement in soil pH by 8 – 17%. Plots receiving compost in both years exhibited the best soil pH response with increases from 10 – 21% (Figure 21).

Figure 22 - Increases in soil organic carbon levels with additions of compost (Initial vs. Final soil samples).

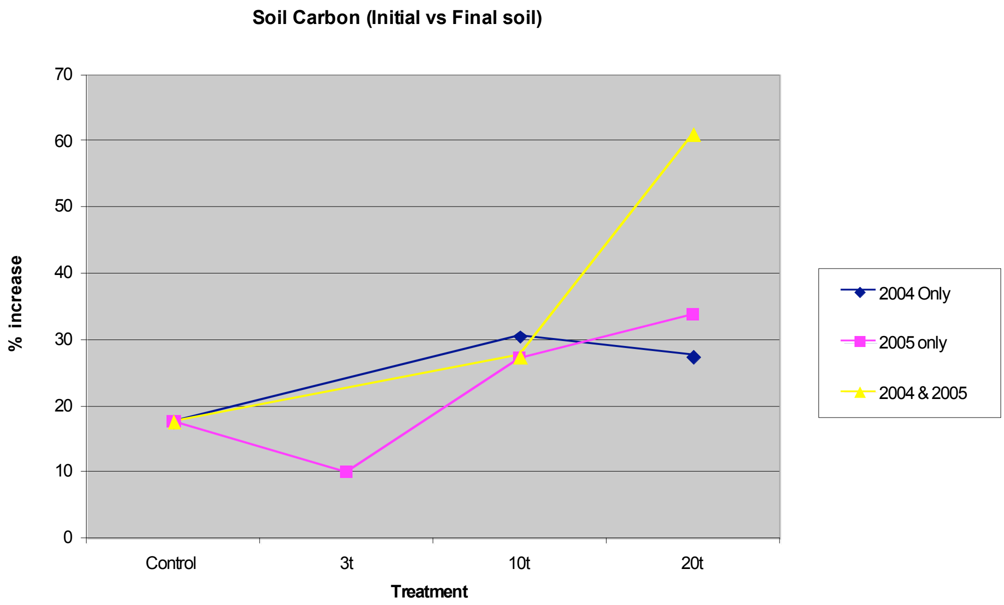


Figure 22 clearly shows the trend is for compost to increase soil organic carbon levels. The control had an increase of 17.6%, while the 10t and 20t treatments had increases from 27% to 61%. The areas treated with 20t compost in both years had the largest increase (61%). The 3t compost performed below the control. This area was treated in 2005 only and is likely to be an anomalous individual result as it goes against the trend. Once again there were residual benefits of using compost with increases in soil organic carbon levels above the control in the 2004 compost only applications.

The 2004 and 2005 broad-acre results showed additions of MSW compost significantly improve aspects of crop growth and subsequent yields. These compost applications can have residual benefits in the following cropping cycle without the need for re-application.

5.2.3 Pellet Program

Pellet Pot Trial - UWA
This complex pot trial provides a guide as to the positive affect of using compost pellet treatments to grow wheat with varying rates of fertiliser. Compost applications increased growth of wheat, both tops and roots.

At the full inorganic fertilizer rate, using 100kg/ha of compost pellets, above ground plant growth increased when compared to the control, but increasing the amount of compost pellets further, decreased the above ground dry matter relative to the control. At the half fertiliser rate, all pelletised compost treatments produced more above ground growth than the control. Above ground dry matter decreased dramatically when pots received only organic fertilisation via the compost pellets (Figure 23).

Figure 23 - Average shoot dry weight of wheat at anthesis.

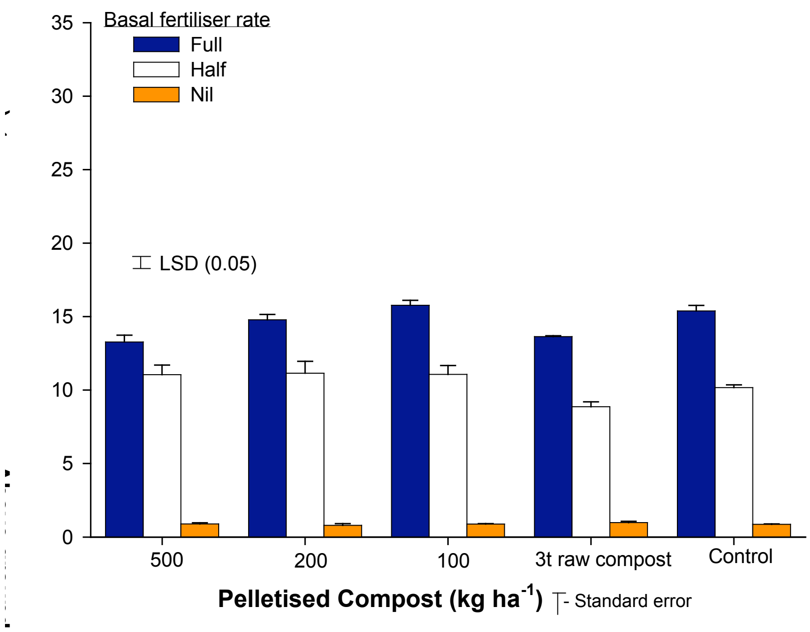
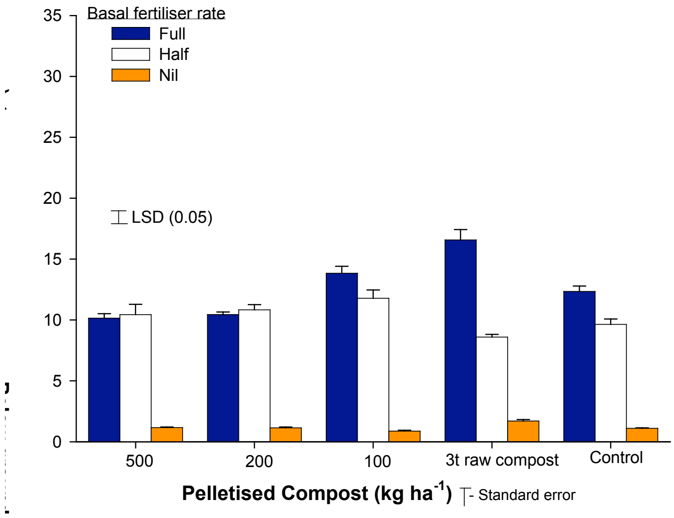
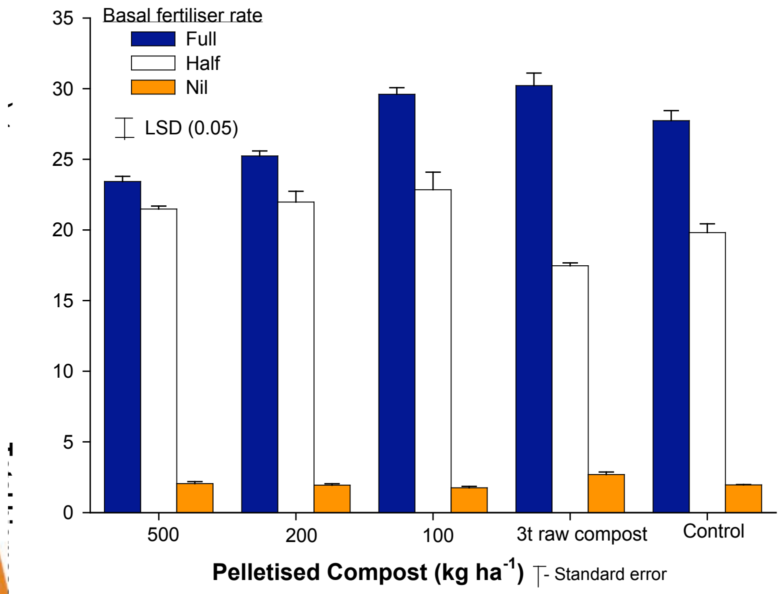


Figure 24 - Average root dry weight of wheat at anthesis



The below ground results (Figure 24) were more positive for compost pellets with increased root growth from all rates of pellets at the half fertiliser level. At full fertilisation the 100kg/ha pellets produced the highest root dry matter production of the pellet treatments. Similarly to shoot growth, increasing levels of pelletised compost caused a decrease in root growth at the full and half inorganic fertiliser treatments.

Figure 25 - Average total dry weight of wheat at anthesis.



Total dry matter production (Figure 25) for the 100kg/ha pellet rate was significantly higher than the control at the half and full fertiliser treatments. The 3t/ha of normal compost (unpelleted) produced the highest amount of dry matter at the full fertiliser rate but interestingly the lowest amount at the half fertiliser rate.

On Farm Pellet Demonstrations
Unfortunately, the two on-farm pelletised compost demonstration trials did not produce useful results.

The Beverley wheat trial was established in early August 2005. The farmer had sown an Arrino wheat crop at the break of the season but heavy rain and poor drainage led to the ground becoming waterlogged in a small area (approximately 5 hectares). The crop had not progressed after sowing and needed to be re-sown. Pellets were delivered in late July and a trial area selected and pegged out. The farmer calibrated the seeding machinery to deliver 100kg/ha of pellets along with the seed (T1), sowed a strip of crop through the paddock, then recalibrated to 200kg/ha pellets and sowed another strip alongside (T2). The gap between strips acted as a control/buffer zone. This was completed soon after pellet delivery once the ground had dried out sufficiently.

The results from this trial were inconclusive with no significant differences observed in any of the soil or plant parameters examined (same program as the standard broad-acre demonstration trials). The trial site didn't fully recover from the early soil waterlogging, experienced residual effects of farmer applied herbicide and was exposed to several severe frost episodes which left the grain bleached and shrivelled.

The summer sorghum trial in Dandaragan did not proceed past the initial trial establishment phase. Pellets were supplied to the farmer in September 2005 during a farm visit to establish a trial site. At this stage the ground for the trial area had yet to be prepared by the farmer so the Project Team provided instructions and sample bags/supplies to establish the trial. Numerous attempts were made by the farmer to prepare the chosen trial area but excessive soil moisture, difficulties in setting up existing machinery to deliver the pellets and time constraints led the farmer to the decision to abandon the trial for the 2006 season.

5.3 Horticulture

5.3.1 Horticulture 2004/2005

During the 2004/2005 season, visible differences were noticed between treatments in some crops. The most obvious were leaf colour differences in wine grapes (see Photo 12), worm numbers under compost mulch and root development in olives.

Photo 20 - Grapevine leaf colour differences between compost treated vines (left) and untreated vines (right)

There were varying amounts of plant nutrients and organic matter applied to the trial plots according to the batch of compost each site received. Table 6 outlines the nutrients applied to each of the T2 plots (highest rate of compost).

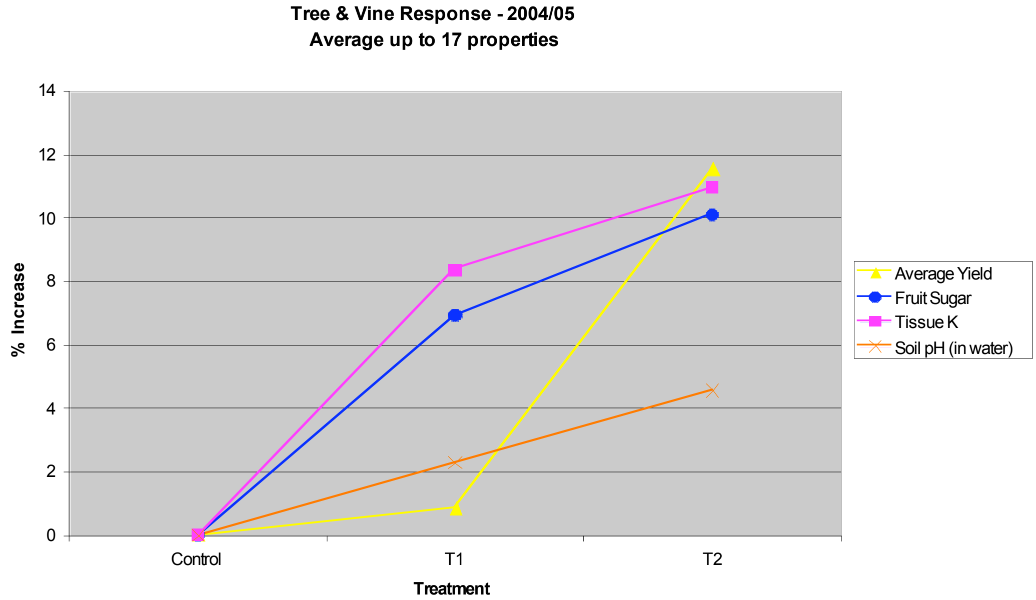
Photo 21 - A visual sign of soil health – Increased worm numbers under compost.

Photo 22 - Increased root growth was observed in olives

Table 6 - Nutrients applied in compost (T2), by farm (kg/ha).

Property	Nitrogen	Phosphorus	Potassium	Organic Matter
Carabooda HN10	187	34	22	12,199
Carmel HE06	324	45	24	17,626
Dwellingup HS04	374	46	43	11,178
Dwellingup HS05	508	65	189	9,657
Gingin HN01	684	114	342	29,567
Gingin HN02	138	26	14	10,037
Gingin HN03	144	46	124	8,960
Gingin HN04	228	58	124	8,617
Gingin HN05	374	32	95	15,129
Gingin (West) HN07	396	55	157	23,657
Gingin (West) HN07B	114	7	5	2,497
Harvey HS01	26	26	7	9,792
Hackett's Gully – HE05	87	26	35	18,360
Jarrahdale HS07	259	56	48	23,501
Karragullen HE01	8	57	21	17,054
Karragullen HE02	187	43	71	7,151
Serpentine HS02	324	45	24	17,626
Swan Valley HN06	461	20	20	7,384

Figure 26 - Average tree and vine response during 2004/2005 season



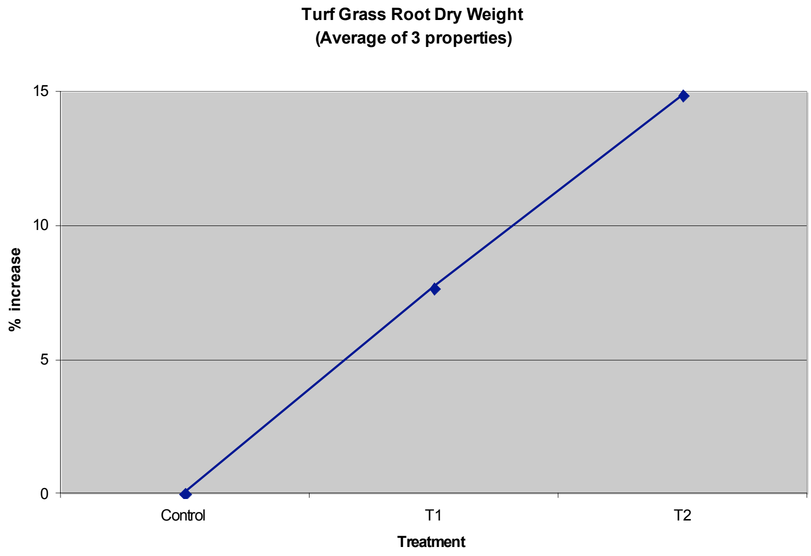
Average fruit sugar levels across a range of crops increased 6.9% under the T1 (25mm) compost and 10.1% under the T2 (50mm) compost treatment (Figure 26). Individual properties increased sugar levels by up to 5% in apples, 13% in wine grapes and 20% in nectarines.

The mid-season testing showed a consistent increase in soil pH measured in water (from acidic starting points) as compost application rates increased (Figure 26).

Tissue testing also showed increases in potassium levels of 8.4% in T1 and 11% in T2. This result was not repeated with other macro-nutrients tested (Figure 26).

Average yields improved by an average of 11.6% in T1 and 0.9% for T2 (Figure 26).

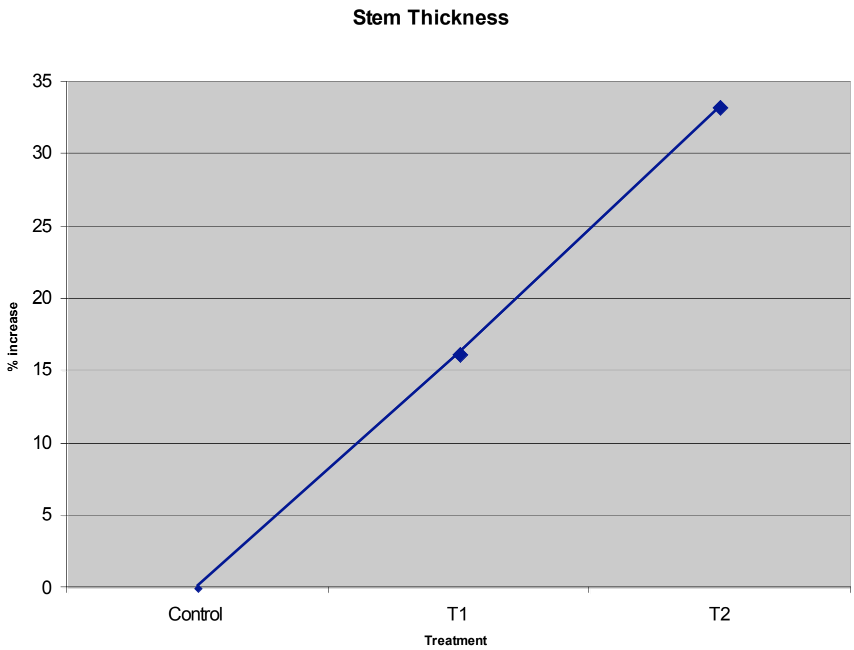
Figure 27 - Compost applications increase turf grass root dry weight.



Increasing amounts of compost application increased root dry weights in turf grass (Figure 27). All participants using MSW compost on turf grass also reported faster turf re-establishment after harvest.

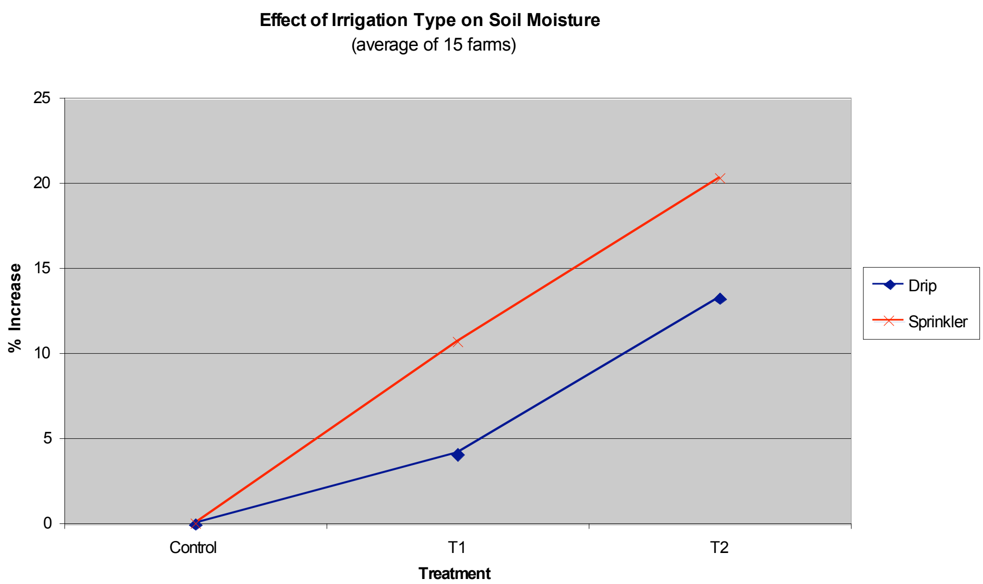
Stem thickness changes (growth over time) were recorded for young trees or vines not producing fruit during the course of the project

Figure 28 - Stem thickness changes in response to compost application (Average of 5 properties).



Stem diameter changes increased when compared to the control, by 16.1% in T1 and 33.3% in T2 (Figure 28).

Figure 29 - Effect of irrigation type on soil moisture content (mid crop sample)



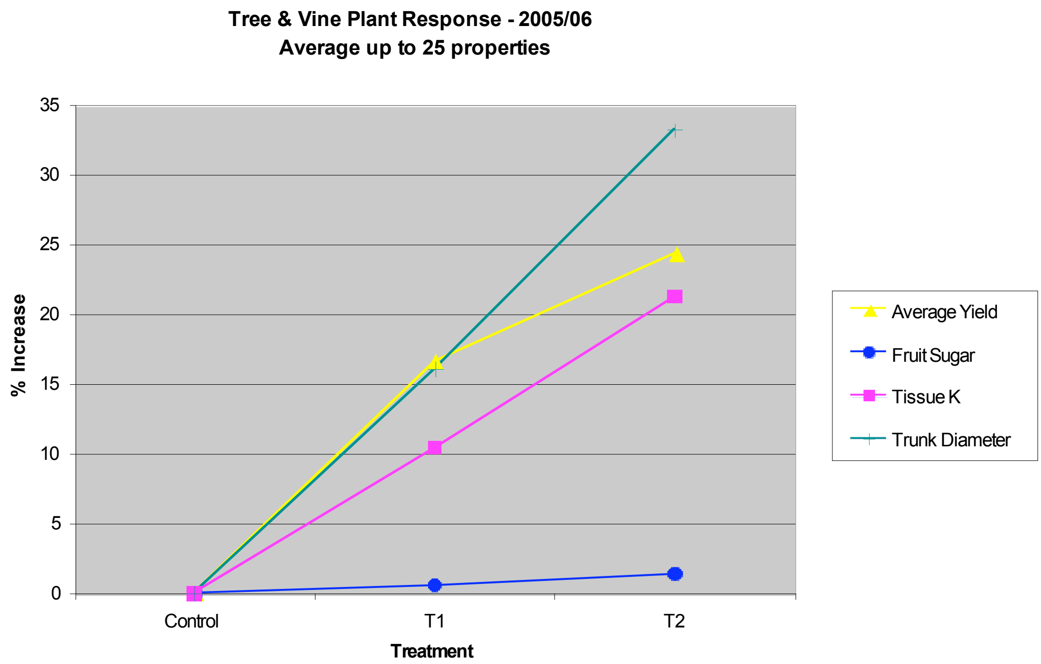
The average moisture level in the soil underneath the compost layer was increased by 20% in T2 under sprinklers and 13.3% under drip irrigation when compared to the control (Figure 29). Soil moisture levels under drip irrigation were lower than the level under sprinkler irrigation.

During the 2004/2005 season there were several improvements in horticultural production which could not be quantified at the time of sampling but were reported by project participants. One such benefit of MSW compost was evident in stone fruit. Participants noted that the uniformity of ripening within a tree row was greater than in untreated rows and post harvest characteristics such as fruit firmness were improved in compost treated areas. Participants also reported that irrigation events could be reduced in both duration and frequency in areas where compost had been banded (T2).

5.3.2 Horticulture 2005/06

During the 2005/2006 horticultural season, the positive responses to compost application seen during the 2004/2005 season were repeated.

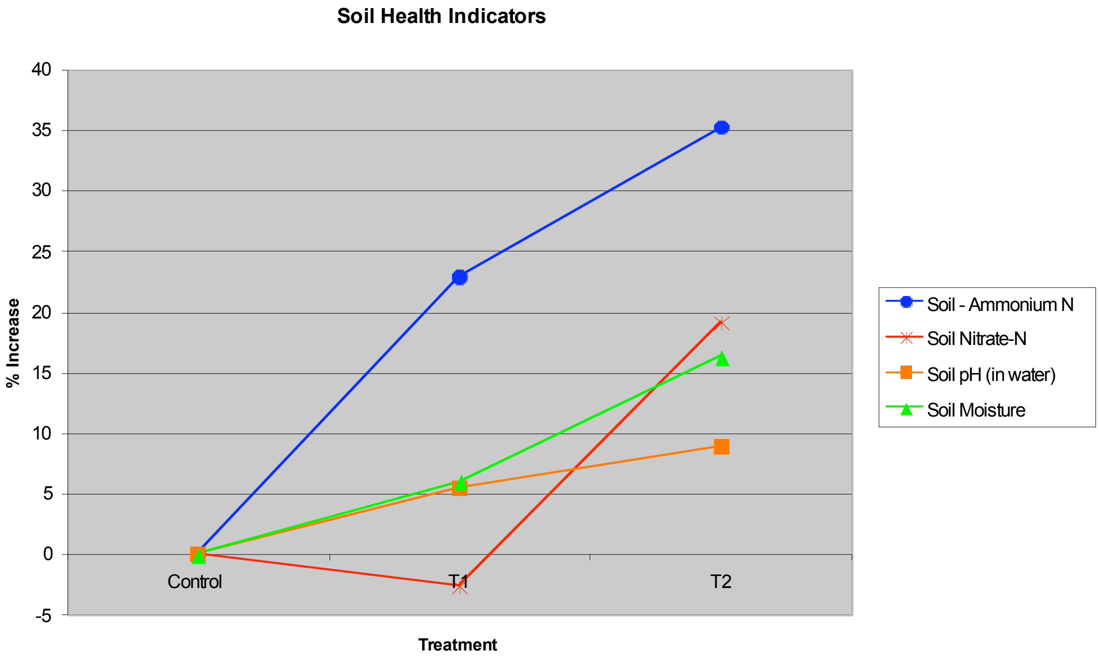
Figure 30 - Tree and vine response to compost application during the 2005/2006 season.



The average yields of all tree and vine crops (ie. bunch weights in grapes, or individual fruit weights in tree crops) were increased by 16.7% in T1 and 24.4% in T2. The most important aspect of this result is that these yield increases were gained without having an adverse effect on fruit sugar content. The average fruit sugar content of all tree and vine crops increased by 0.6% and 1.4% with increasing amounts of compost application (Figure 30).

Analysis of the nutritional status of leaf tissue samples in horticultural crops revealed that tissue potassium (K) levels increased by up to 21.2% with increasing amounts of compost application. The tissue K response was by far the most significant and consistent tissue nutrition response of all the macronutrients analysed (Figure 30).

Figure 31 - Soil response to compost applications during the 2005/2006 growing season.



Soil nitrogen levels were significantly increased with compost applications. Soil ammonium-N levels increased by 22.9% and 35.2% with increasing amounts of compost applied. Soil nitrate-N levels increased by 19.1% at higher rates of compost (Figure 31).

Soil pH (in water) increased by 5.5% at T1 and 8.9% at T2. This was a positive response as all soil pH levels were initially in the acidic range. There was a similar positive response in soil moisture levels with moisture increasing by 6% and 16.3% with increasing amounts of compost application (Figure 31).

Soil Moisture / temperature monitoring

Installation of data-logged gypsum blocks and soil temperature probes at a northern horticultural trial site allowed soil moisture and soil temperature to be compared under compost treated and control rows of young citrus trees. The results showed that under the compost layer, soil temperature was reduced and the soil was able to retain moisture at a higher level for longer periods of time. When interpreting the soil moisture results below it must be noted that higher soil water tension measured in kilopascals (kPa) represents lower soil moisture content.

Figure 32 - Soil moisture 10cm under soil surface (7 - 27 January 2006).

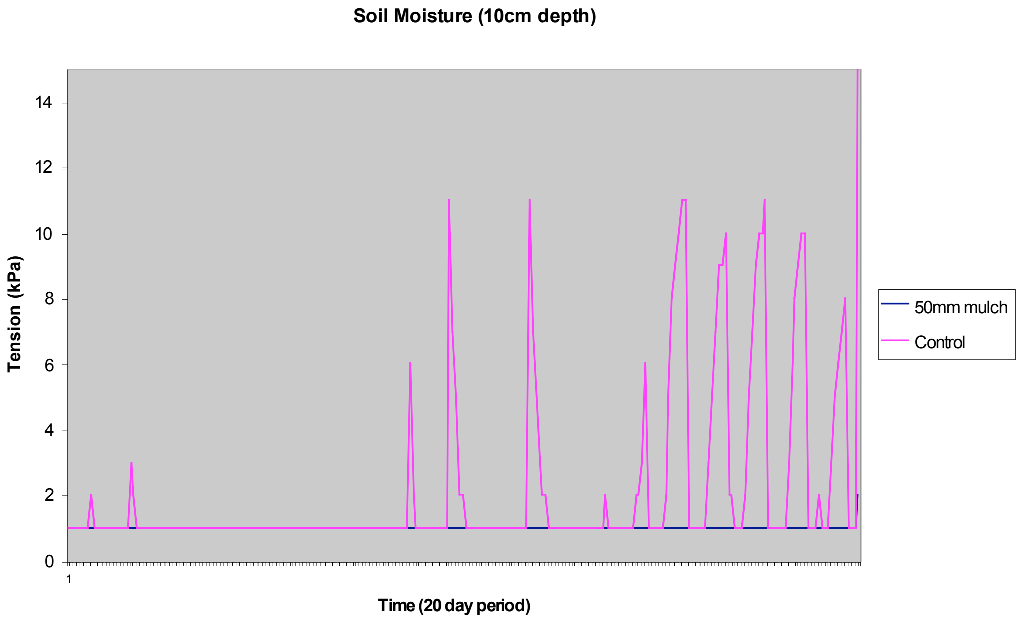


Figure 32 shows that during the monitored period the soil moisture content under the mulch layer remains constant around 1 kPa (visible when control water tension rises above 1kPa in Figure 32). This indicates the soil at this depth is constantly wet. Soil moisture in the control row can be seen to rise and fall between 1 and 10kPa. Towards the latter half of the monitoring period this can be seen happening on a daily basis. These results show the soil in the control rows (no compost) is subjected to a cycle of partial drying and wetting that is absent under the compost mulch layer. It should be noted that under the frequent irrigation program (dictated by the grower) the soil is not allowed to dry out to any significant degree at any time.

Figure 33 - Soil moisture 60cm under soil surface (13 November – 9 December 2005).

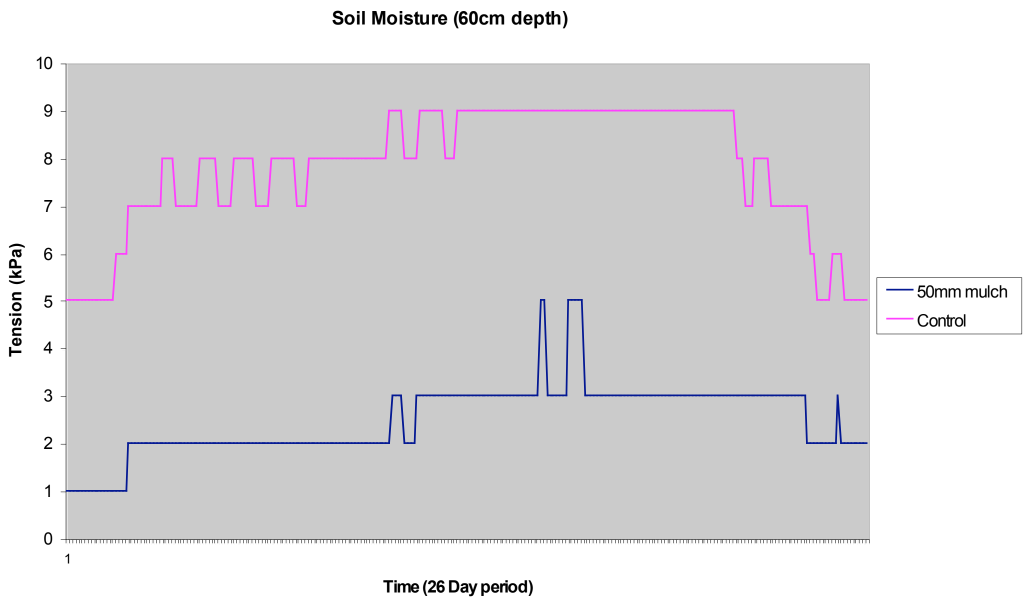


Figure 33 shows that during the monitored period the soil in the control row has lower soil moisture levels (higher water tension) at all times when compared to the soil under the compost mulch. It should be noted soil moisture content in both treatments is at the wet end of the moisture spectrum due to the frequent irrigation events scheduled by the grower.

Figure 34 - Soil temperature 10cm under soil surface (16 – 20 January 2006)

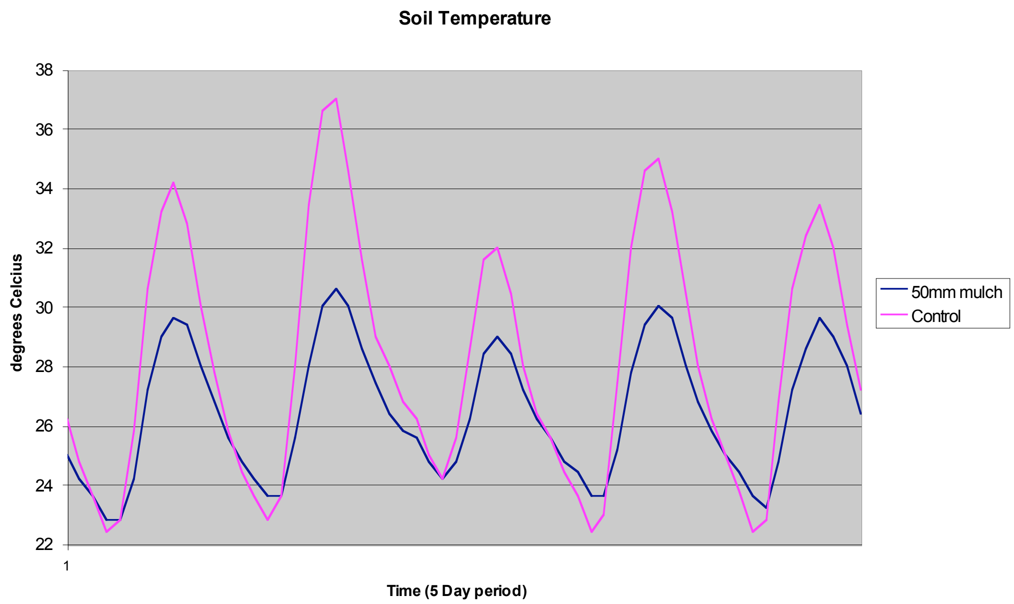


Figure 34 shows soil temperature measured 10cm under the soil surface is noticeably reduced when compost is present as a mulch layer. There was up to a 20% decrease in soil temperature during the hottest part of each day under the mulch layer and marginal advantage in retaining heat during the night on some days. This effect was consistent over the whole period of soil temperature monitoring (3 months).

5.4 Heavy Metal and Pesticide Residues

Soils from participating farms were analysed for the level of heavy metals and pesticide residues prior to each application of compost and also at the end of the project. Each batch of compost utilised was also analysed for heavy metal and pesticide residues.

Table 7 below compares the average farm soil contamination levels after treatment with MSW compost with the control. In all soils, after 2 years of compost treatment at 20t/ha, all soil contaminants levels were well within the allowable levels in the Biosolids Guidelines.

Variations were observed in successive soil samples and even laboratory analysis of the same samples varied as much as 30%. Whilst in some cases there may appear to be trends, there was however, no consistent additive effect correlated to the amounts of compost applied to any particular area.

Table 7 - Average soil contamination levels across all farms

Contaminant	**Broad-acre**			**Horticulture**		
	Control 2006	**Treatment 2 2005**	**Treatment 2 2006**	**Control 2006**	**Treatment 2 2005**	**Treatment 2 2006**
Arsenic	<5	<5	<5	<5 *	<5 *	<5 *
Cadmium	<0.01 *	<0.01 *	<0.01 *	0.2	0.1	0.2
Chromium	18	28	16	22	21	23
Copper	4	7	7	17	14	17
Lead	9	5	11	6	9	12
Mercury	0.03	0.04	0.04	0.03	0.03	0.05
Nickel	4	5	5	3	4	4
Zinc	5	8	10	24	12	34
Dieldrin *	ND	ND	ND	ND	ND	ND

ND Not Detected
* Most properties had levels below the detectable limit

Compost average heavy metal and pesticide residue levels are below the C1 guidelines for unrestricted use of compost for all measured contaminants except for lead, zinc, chlordane and dieldrin. This means the compost is C2 standard, on average, which requires a monitored approach for use in agriculture.

Table 8 - Average chemical contaminant levels in MSW compost compared to biosolids guidelines.

Analyte (ppm)	Compost Average	Biosolids Guideline C1 Maximum	Biosolids Guideline C2 Maximum
Arsenic	4.92	20	60
Cadmium	1.13	3	20
Chromium	26.72	100	500
Copper	90.49	100	2,500
Lead	182.14	150	420
Mercury	0.30	1	15
Nickel	19.80	60	270
Zinc	336.65	200	2,500
Aldrin	0.015	0.02	0.5
Chlorpyrifos	0.212	NA	NA
Chlordane	0.022	0.02	0.5
Dieldrin	0.089	0.02	0.5
DDT/DDD/DDE	0.079	0.5	1.0
Lindane	0.018	0.02	0.5

5.5 Farmer Survey

Table 9 - Farmer views on MSW compost – April 2006

Question (and Answer)	**Yes**	**No**
Q1. Did the compost meet your expectations?	Yes 73%	No 27%
If not, why? Expected a better crop response		
Q2. Have your views on compost changed due to the project?	Yes 40%	No 60%
Q3. Overall impression of compost quality?	Positive 91%	Negative 9%
Q4. Comments on ease of use and integration into normal farming practices	No problems 81%	Problems 19%
Q5. Identify limitations to further compost use - freight costs - cost:benefit uncertainty - compost contaminant build up		
Q6. Improvements you would like to see? - decrease compost contaminants - decrease dust - increase bulk density - pelletise compost - improve wettability		
Q7. Did you see visual improvements?	Yes 55%	No 45%
Q8. Are you interested in further trials?	Yes 86%	No 14%
Q9. Are you interested in pelletised compost trials?	Yes 82%	No 18%
Q10. What price would you pay for compost?	$20/t + freight	Broad-acre 0 Horticulture 0
	$10/t + freight	Broad-acre 1 Horticulture 9
	$5/t + freight	Broad-acre 1 Horticulture 1
	$0/t + freight	Broad-acre 3 Horticulture 2
	nothing	Broad-acre 2 Horticulture 1

Twenty two farmers completed surveys (48% response rate) and the majority of responses to the survey were positive in terms of compost performance and assessment (and constructive in their criticism). A great deal of feedback from farmers came from conversations between the participants and the Project Team during farm visits, field days and personal correspondence. Relevant anecdotal feedback is included here.

Of respondents 73% confirmed that the compost had met their initial expectations. Throughout the trial period there were numerous comments from participants that the compost had exceeded their expectations. For those who responded in the negative, the major reason given was that they were expecting a better visual crop response than they observed in the trial area.

40% of respondents replied that their views had changed due to the demonstration project. Most of the changes stated were in the positive. The 60% of respondents that had not changed their views are in line with earlier market research (Market Equity 1999) that showed that farmers are aware of compost and its benefits.

91% of respondents had a positive impression of compost quality. These participants noted that the compost had good physical characteristics and little or no adverse odours. Of the respondents that had a negative impression, the identified characteristics of compost quality were that it was “dusty and smelly” and contained heavy metals and pesticide residues. One response indicated that the compost became hydrophobic (non-wetting) after application.

When asked about the ease of use, 81% of respondents had no problems with integrating compost into their existing farm management schedules.

Of the remainder, the majority of problems encountered with compost were: being time consuming to spread with existing machinery and being difficult to spread when wet.

Existing spreading machinery found on most broad-acre farms is suitable for compost application. However the time required spreading the high volumes of compost required to achieve a yield response over large areas of land, makes it impractical for many farmers. As farmers and growers already have significant demands on their time from other aspects of operational management this was seen as a problem.

The moisture content of the compost can change from batch to batch, but more significantly once it has been delivered to farm (depending on storage conditions). If the compost is exposed to excessive amounts of water, it can rapidly increase in moisture content and become difficult to handle. Participants reported incidences when compost would stick to the sides of delivery trailers and prove difficult to unload, and would “hang up” on the sides of spreading machinery, decreasing spreading efficiency. This type of operational issue is resolved with greater farmer experience with compost.

When asked to identify the major limitations to the further use of compost, respondents were consistent across industry sectors. Freight costs, clear demonstration of the cost-benefit of compost use, and heavy metal and pesticide residue build-up in soils were the three major limitations identified.

Freight costs for all off-farm sourced inputs are a growing concern for modern agricultural and horticultural operations due to the rising cost of diesel fuel used in transporting these inputs to the farm gate. Given the large volumes of compost needed per unit area (due to its low bulk density) and the large distances from compost source to farm gate, compost freight costs represent a significant proportion of the total cost of applying compost.

The cost:benefit analysis of compost use (particularly in broad-acre agriculture) is also critical. Gains in grain yield due to compost use do not deliver sufficient increases in returns per unit area to justify the costs associated with compost use (due to the low prices received for grains at the present time and high total cost base).

Whilst all participants were fully informed of the possible heavy metal and pesticide levels in the compost, and the need for extensive soil testing prior to every compost application, the build up of such contaminants in existing soils was identified as a concern and limitation to further use. There was, however, an acknowledgement from a number of participants that the compost could be used safely by rotating the areas of application from year to year (to make use of its residual value), and using it only in a targeted way on areas requiring organic matter inputs rather than wholesale broadcasting over entire areas.

There were 5 main improvements in the area of compost quality that were suggested by the survey respondents.

- decrease the level of contaminants found in the compost (physical and chemical)
- reduce the “dustiness” of the compost
- increase the bulk density of the compost
- Pelletise the compost
- Increase the “wettability” of the compost

Different aspects of the physical and chemical contaminants in the compost concerned different respondents.

The turf participants felt they could manage the chemical contamination issues but wanted to see a reduction in the glass contamination for their own employee Occupational Health and Safety reasons, and to protect end users (ie turf purchasers) from potential safety issues that may arise from glass fragments being found in turf rolls. 2 of the 3 turf farms participating in the demonstration project have dramatically reduced the amount of compost they are willing to use (and in one case may stop using it altogether) for these reasons.

The grapevine and pasture participants would like to see a reduction in chemical contamination because of concerns over possible contamination of end products by heavy metals and pesticide residues. With the increasing market pressure on these sectors to produce a "clean and green" product to satisfy export markets, a reduction in the contamination levels would ease some of their concerns over using MSW compost. These concerns could be addressed by further study into the possibility (or otherwise) of the contaminants entering the end product via the soil or plant tissue but such research is outside the bounds of this report.

Throughout the project period, numerous participants commented on how dusty the compost was when spreading. This is a function of the moisture content of the compost supplied. Participants were worried about dust inhalation issues for themselves and employees and the fact that the compost was seen to be blowing away from the target application area during spreading.

Increasing the compost bulk density and pelletising of the compost were improvements farmers wished to see. A low bulk density product, such as MSW compost, is costly to freight and requires large volumes of material to be used to achieve target application rates. By pelletising the compost the volume of material can be reduced along with the application rates.

Improving the compost by increasing its "wettability" was a common response from horticultural participants. Several growers noted that the compost became non-wetting after a period of time on the ground and that this had the potential to affect irrigation efficiency. Several sites were examined where compost had become non-wetting. Whilst this had not led to any soil or crop damage it did contribute to the perception amongst growers that the compost may have some limitations (ie the need for compost to be incorporated into the soil to prevent it becoming non-wetting).

When asked if participants had seen any visual crop differences in the compost trial areas, 55% responded positively (with 67% of the positive responses coming from Horticultural participants). Participants noted that horticultural crops produced either more canopy or foliage, darker/healthier leaves, larger grape bunches, more uniform fruit ripening and faster turf re-establishment. Broad-acre growers reported better follow up pasture growth, better crop emergence and higher dry matter production (crop size). These responses were important because there has to be a significant improvement in the underlying health (nutritional or moisture) of the plant to be visible to the naked eye.

86% of participants said they would like to trial compost again in the 2006/2007 season and 82% said they would like to trial pelletised compost on their property during this coming season.

85% of respondents indicated they would be willing to at least pay the freight costs to deliver compost to their property, while 50% indicated they would pay up to $10 per tonne of compost plus the associated freight costs. The horticultural sector provided the largest number of participants willing to pay the highest price ($10/tonne + freight) although five of the seven broad-acre respondents were prepared to pay something for the compost. No farmer said they were prepared to pay more than $10 per tonne plus freight.

The responses concerning the price farmers would be willing to pay for MSW compost must be treated with caution. Anecdotal evidence suggests few are willing to pay for compost at this point in time. Several growers expressed the desire to use compost on a trial basis (ie free of charge) for another season or more before they decide on or confirmed the benefits to be gained from its use. In the latter stages of the project when more compost has become available, farmers have not been prepared to pay for the compost. The most they have been prepared to pay for is the freight.

6. Discussion

Overview

This project's aim was to generate interest in and showcase the advantages of using MSW compost for commercial farmers. It is in the community's interest to encourage farmers to use compost on a large scale as it is not only a way to recycle waste and reduce the amount of material going into landfill, but a way for farmers to improve their soil. Today most agricultural businesses rely on synthetic fertilisers (significant pollutants within themselves) to feed nutrients into their crops. Compost is not only a source of nutrients, it offers long term benefits for sustainable soil management and water retention that fertilisers alone are unable to achieve.

This project has demonstrated to a significant number of farmers on a large variety of broad-acre and horticultural properties the many benefits of MSW compost. There was some doubt in the farming community whether compost made from municipal solid waste could be turned into something useful. The results of this project have clearly demonstrated MSW compost improves soil health and crop performance.

Results on all farms using MSW compost have shown consistent soil fertility improvements particularly in the area of soil moisture, organic carbon and pH (reduced acidity). On broad-acre farms this was represented in obvious soil moisture improvements in the dry 2004 season and in horticulture by increased soil moisture and retention of soluble nitrogen in the root zone.

Improved crop performance was highlighted consistently by extra plant growth, higher yields and in many cases improved quality of produce. In broad-acre crops this was evident in improved plant dry weights, tillering and grain yield. In horticultural crops improved performance was reflected in increased tree and vine growth rates, higher turf production, increased fruit yield and sugar content.

These improvements are the result of compost's unique ability to increase organic matter in the soil and improve soil structure, that is improve the quality of the soil. With soil degradation being a significant problem in West Australian soils, compost has the potential to provide long term solutions to sustainable soil management. Compost increases a soil's ability to retain moisture and fertiliser in the plant root zone. This leads to more efficient use of irrigation water and fertiliser, potentially reducing the amount of fertiliser polluting ground water.

There was no consistent effect of compost on soil heavy metal and pesticide residues and soil contaminant levels were well within the allowable levels in the WA Biosolids Guidelines. Soil samples taken over time from the same untreated areas varied considerably in terms of heavy metal and pesticide residue content. This is thought to indicate variability in the distribution of these contaminants and lack of accuracy of current laboratory techniques.

For individual farmers, improvements from compost are only significant if there are higher profits to be made. The increased financial returns arise primarily from the higher yields or from reduced cost of other inputs. The demonstration project has shown improved yields in broad-acre and horticulture with clearly higher yields and profits in wine grapes, stone fruit, and turf. Cost-benefits were not clearly demonstrated in most broad-acre trials as compost was an additional input. Significant cost savings will be evident when farmers integrate compost into their farm management plan and reduce the use of other inputs. Farmers need help and encouragement to do this, but at present there is little experience in the farming community, within the Agricultural Department or with agricultural consultants as to how to allow for the available nutrients in compost combined with the extra nutrient holding capacity of compost to reduce fertiliser use. It is important stakeholders are given training in this area if compost is to be used more widely.

The three main logistical issues encountered were - restrictions on which roads a road-train can operate on, availability of trucks to cart low bulk density material and to a lesser extent availability of spreading equipment (availability of equipment in horticulture; volumes spread per hectare in broad-acre).

Farmers overwhelmingly provided positive feedback that the compost had met or exceeded their expectations. The few farmers who responded in the negative were expecting a better visual crop response than they observed. Twenty two farmers completed a survey at the conclusion of the project and these participants noted that the compost had good physical characteristics and little or no adverse odours. Of the respondents that had a negative impression, the identified characteristics of compost quality were that it was “dusty and smelly” and contained heavy metals and pesticide residues.

During the 2004 growing season it became evident there was a need to improve the practicality and cost-effectiveness of MSW compost use on broad-acre farms. Discussions with broad-acre farmers highlighted the need for a product that was easier to freight and used lower application rates, preferably via their seeding equipment to minimise the “number of passes across the paddock”. Consequently initial trials were conducted during 2005 to provide an indication of the cost-effectiveness using pelletising MSW compost in cereal crops. These trials provided a positive yield response at low application rates (100kg/ha) and will be repeated on a broader scale in 2006.

The compost market is at different stages of development, depending on the market segment. These segments are:

- Domestic/landscape market for compost and mulch, including the soil blending industry,
- Commercial crop production, and
- Land rehabilitation

This project focussed on the agricultural segment as it is the largest underdeveloped market segment.

6.1 Reasons for yield improvements

Yield improvement on all farm types from using MSW compost, have been the result of soil fertility improvements primarily in the areas of increased organic carbon, soil moisture, nutrient retention and microbial balance (aerobic to anaerobic bacteria ratio). This was most evident on dry-land farms but was also significant in irrigated crops.

6.1.1 Soil Moisture

The soil moisture retention benefits of compost applied to soils are well documented. The organic matter in these compost additions has the ability to absorb relatively large amounts of water (Edmeades 2003, Oades 2004). The soil moisture levels increased in MSW compost treated areas in both broad-acre and horticultural soils indicating the material is performing as would be expected of high quality compost.

Horticulture

In horticultural trials the compost was used as a mulch layer on top of the soil in the tree or vine line. Mulch layers can be established using a wide variety of materials spread over the soil surface. They can protect the soil from erosion, increase soil moisture retention, reduce soil temperatures and suppress weed growth (Porter 2005). Mulches serve as physical barriers that dissipate erosive energy from raindrops, thereby protecting the structure at the soil surface (which increases soil permeability). Mulches also reduce the evaporation of moisture from the soil surface. The mulch layer suppresses weed growth by excluding light from the soil surface and this also has the effect of lowering soil temperatures by providing insulation from direct solar radiation (Porter 2005).

The increased soil moisture level in MSW compost treated areas was consistent with these established benefits of mulch layers. Monitoring soil moisture at different depths throughout the soil profile revealed that soil moisture content was higher in compost treated areas compared to the control areas. Soil temperatures during the hottest part of the day were also reduced under the mulch layer by up to 15-20%.

Increasing the soil moisture in horticultural crops with compost has several advantages:

- Reduces the amount of water required through irrigation as there is more efficient use of the applied irrigation water.
- Irrigation system malfunctions have less of an impact as the soil is able to hold more moisture and reduce the stress on plants when malfunctions occur.
- Reduces water stress on plants, particularly those most susceptible such as grape vines. Grape vines are particularly susceptible to water stress at certain growth stages. Grape yield can be significantly reduced if water stress occurs from flowering to fruit set or shortly after veraison (Lantzke 2004). If the water stress occurs between flowering and fruit set (when berry cell division is most active) there will be a reduction in the size of the berries at harvest because smaller numbers of cells are available for fruit development (Goodwin 2002)

Broad-acre

In this project, 2004 was a relatively low rainfall season, while 2005 was relatively high. This enabled a comparison of the impact of compost with variations in rainfall. Even though the trend was for trial sites with compost to have improved yields in both years, a closer examination of the results for broad-acre crops gives information about the specific benefits of compost in the different growing conditions. The impact of the variations is especially pronounced in broad-acre farming where the crop is reliant solely on rainfall events for all its water requirements.

In the drier 2004 season, soil moisture in broad-acre crops treated with compost was noticeably higher, as were the yields. This suggests compost increased the soils ability to retain moisture, which is consistent with other findings in the literature (Edmeades 2003), and resulted in improved growth. If rainfall is limiting, the presence of compost means the crop can access soil moisture over a longer period of time and in greater quantities. The 2004 growing season was characterised by below average summer rainfall, average to below average starting rains and a critical absence of rain during the flowering and grain setting/filling period.

This deficit in rainfall meant yields across the regions studied were generally below average and in some cases severely reduced. The areas treated with compost in 2004 showed improved tillering and grain yields (up to 40%) over and above the control areas. It is thought these increases arose because of improved soil moisture holding capacity in compost treated areas when rainfall was limiting. In effect, the addition of compost can be thought of as the crop experiencing an extra rainfall event during the critical growth stages of the season.

The 2005 growing season was characterised by low rainfall in the first three months of the year, above average rainfall in April, May and June, above average rain during the critical flowering and grain filling period and average finishing rains. The above average rain at the beginning of the growing season and into the first month of the crop caused several problems of its own. Crops could not be sown due to excessive soil moisture (waterlogging) and weed growth accelerated as farmers were unable to enter paddocks to apply herbicides. Yields produced by trial areas were still above average compared to controls. As the season was particularly wet, soil moisture was not significantly different between treatments. However increased plant tissue nutrient levels, particularly potassium, indicates plants were able to take up more nutrients, which may be attributed to more efficient use of applied fertilizers or enhanced soil microbe activity rather than increased soil moisture holding capacity.

Table 10 - Annual rainfall figures for 2004 and 2005 in demonstration site areas

Location	2004 Total (mm)	2005 Total (mm)	Long Term Average (mm)
Brookton	304	502	451
Gingin	519	737	749
Williams	451	527	541
Northam	347	407	439

2004 was a below average rainfall year which suggest the positive yield responses to compost applications came from increased moisture retention at critical times.

2005 was a higher rainfall year which suggested the yield increases in plots with compost applied came about through increased fertiliser use efficiencies.

6.1.2 Soil type

There were a range of soil types included in the trials ranging from low performing sands to brown loams and grey sandy clays. Positive responses to compost were achieved on all soil types, but the response was greatest on sandy soils. This reinforces the current knowledge on compost use in horticulture (Paulin et al 1998).

Within the horticultural demonstration trials, variations in soil type across the trial area had less of an impact on results. In dry-land farmed situations, poor soils cannot retain as much moisture as higher quality soil (with more clay). The irrigation on horticultural farms is normally adjusted to optimise soil moisture levels for the individual crop and soil type, providing adequate water to the crop and reducing the effect of moisture retention capacity of soils. The smaller horticultural trials also meant that soil was more uniform on trial sites.

In broad-acre crops the soil type had a major bearing on the effectiveness of the compost. Sandy soils have less ability to retain moisture and applied fertilisers than do heavier loam or clay soils (Moore 2004). At the onset of this project it was expected the best response to compost would be in the lighter, sandier soils as these were the ones that would most benefit from increased organic matter (from the compost). Increasing soil organic matter is the best way to improve a soils ability to retain moisture and applied fertiliser (Edmeades 2003).

In the 2004 broad-acre season, 6 out of 8 of the best compost responses (as measured by crop yield increases) were from properties with light sandy soils. In the 2005 broad-acre season, 6 out of 7 of the best compost responses were from properties with light sandy soils. The majority of these properties had low initial organic matter contents.

6.1.3 Stubble management

How farmers manage stubble had an impact on the effectiveness of compost. Within the broad-acre trial sites there were a number of differences in stubble management techniques. Some growers chose to remove the previous year's crop stubble by raking and removing or burning whilst some growers chose to retain stubble. These differences amongst growers arise due to the differing thoughts on stubble retention and long term paddock management goals, the choice of seeding machinery, time constraints or previous paddock management difficulties (eg plant disease or weed management). The impact of these grower choices on compost demonstration trial performance was significant, with farmers retaining stubble having improved yields with compost compared with those who removed the stubble.

Removing the stubble (either by raking and bailing or burning) before spreading compost leaves the ground surface exposed and susceptible to wind damage. Some farmers choose to rake and burn the previous year's crop stubble. This is practiced to improve weed, insect and disease control in the next crop and to remove any physical impediment that stubble can be when seeding the new crop (DPIWE 2005). If a farmer chooses to rake and burn stubble they face the disadvantage of increasing susceptibility to soil erosion by wind and water prior to seeding (DPIWE 2005).

Soil organic matter is particularly mobile and compost which has been spread onto paddocks where stubble has been raked and burned, can be blown or washed away by unexpectedly strong winds or heavy/intense rainfall. This occurred on two broad-acre properties (BE08 & BE09) at the start of the 2004 season when a strong wind event occurred in the days after compost spreading and before crop seeding. There were 7 broad-acre trials established (compost spread) in the area at this time and visual examination of these trial sites after the storm revealed that up to 90% of the applied compost and a portion of the topsoil had been eroded away on the two sites where stubble had been removed. On the 5 farm sites where stubble had been retained, the majority of applied compost still appeared to be in place with no noticeable topsoil erosion.

Despite the visual loss of applied compost in the treated areas there appears to have been some retained value with 10-11% yield improvement on one farm and 24-35% increase on the other (albeit with variable yield improvement). The other trials where stubble was retained exhibited increased average yield responses in line with compost application rates.

Photo 23 - Compost (settled on the ground) is protected by stubble from the previous crop

Photo 24 - Where stubble was raked and burned before compost application, a severe wind event eroded the compost and some of the topsoil away

6.1.4 Soil Microbes

Additions of MSW compost increased the ratio of aerobic to anaerobic bacteria and the number of *Actinomyces* bacteria found in the trial soil samples. Aerobic bacteria utilise oxygen in their growth and represent a very diverse and important section of soil micro-organisms. High numbers of aerobic bacteria in a soil sample is generally indicative of soil conditions conducive to good plant growth. Anaerobic bacteria are capable of growth in the absence of oxygen. High numbers of anaerobic bacteria in a soil sample usually indicates that the soil is poorly aerated (either waterlogged or compacted).

The ideal ratio of aerobic bacteria to anaerobic bacteria is considered to be between 10:1 and 15:1 (bbclabs.com) and is indicative of a well balanced soil microbial population. Additions of MSW compost to broad-acre soils increased the aerobic:anaerobic ratio from 3:1 in control areas up to 15-20:1 in compost treated areas. This suggests the compost provided the soil with a new source of microbes and a food source for existing microbial populations and improved soil physical conditions to allow aerobic bacteria to thrive (Ingham 2004).

Actinomyces are a group of bacteria found in soil that play an important role in the decomposition of organic matter, replenishing the soil with nutrients and producing humus. Most members of the group are aerobic and favour moist, well aerated soils (Groth and Saiz-Himenez 1999). Actinomyces prefer alkaline soils (optimum pH is 6.5 – 8) and are almost non existent in soil with pH less than 5. Organic matter additions also stimulate actinomyces populations (Titus and Pereira 2005).

Additions of MSW compost increased the numbers of actinomyces found in soil samples by 25 – 150%. This result shows that the compost, which has added organic matter, increased soil pH and increased moisture retention in treated areas, has stimulated the growth of these beneficial soil micro-organisms.

6.2 Environmental advantages of compost

The use of MSW compost in agricultural and horticultural operations has a number of benefits to the environment. They include:

Waste diversion

Converting MSW into healthy compost which can be used to improve the productivity of agricultural and horticultural enterprises has a huge potential to divert household waste away from diminishing landfill resources. The community benefits are numerous:

- Reduced land fill area requirements in urban areas
- Reduced greenhouse gas emissions caused by organic material decomposing in land-fill
- Less environmental impact from leachate entering underground water resources under land fill zones
- Land previously zoned for landfill can be freed up for more productive uses
- Reduced costs associated with transporting MSW to landfill zones further and further away from the generating sources.

By converting MSW into a value added product such as compost for use on farms, we as a community are returning organic matter back to the land and "completing the organic matter loop".

The need to produce a quality assured MSW compost and assist in its redistribution back to the originating source was identified by the WA Department of Environment as part of the "Towards Zero Waste: Actions for the Green and Organic Sector" Waste 2020 Task Force recommendations (Dept of Env 2001).

Fertiliser leaching

Applying compost to soils can aid in reducing the amount of fertiliser leaching from soils (Edmeades 2003) which has two main benefits: fertilisers are held in the root zone where they can be taken up by the plant which increases the efficiency of use of applied fertiliser; and a reduction in the amount of fertiliser potentially polluting ground water resources.

Moisture retention

Additions of compost increase a soils ability to retain moisture in a plants root zone which leads to greater crop performance and better irrigation water use efficiency. By holding moisture in the root zone the incursion of salty subsurface water can be minimised. This limits the damage to crop production that occurs with salt incursion (Maas and Hoffman 1977).

Ameliorate salinity

The area of productive land adversely affected by rising salinity levels is rising dramatically. In 1997, the area affected in WA alone reached 1.8 million hectares or 9.4% of cleared farmland (George et al 1997). It is estimated that this figure could approach 4.4 million hectares by 2050 (Olive 2001).

The use of compost to ameliorate soil salinity has potential as additions of organic matter into soil increases water infiltration and the potential for salt to be displaced from the root zone, and had been linked to improved soil structure and aggregation (Tisdell and Oades 1982, Oades 1988). Humic substances and humic carbon (components of compost) have also been shown to reduce the effect of salt on the germination and growth of certain species of plants (Masciandaro et al 2002).

If the benefits of using MSW compost on salt affected land could be demonstrated, it would open up a huge new market for this material and provide farmers with a valuable management tool to reclaim areas of currently non productive or marginal land.

Significant interest was expressed by several local Landcare groups to trial compost on salt affected pasture paddocks but limitations on available trial sites during the course of the project prevented this from occurring.

6.3 Heavy Metal and Pesticide Residues

Composts made from municipal solid waste contain trace amounts of metals and pesticide residues. Metals can be introduced into the municipal waste stream from a variety of sources including batteries, consumer electronics, ceramics, light bulbs, house dust, paint chips, lead foils such as wine bottle closures, used motor oil, plastics and some inks and glass (Woodbury, 1996).

Some of these metals are important for plant growth, eg copper, zinc, nickel (for legumes), and soil deficiencies are more common than toxicities for these metals. Other metals such as arsenic, cadmium, lead and mercury are of a concern due to their toxicity to animals and humans (Woodbury, 1992).

The Australian Standard for compost (AS4454-2003) refers to state guidelines for the appropriate levels of heavy metals and pesticide residues in compost and soil. The relevant guidelines in Western Australia are the Biosolid guidelines (Western Australian Guidelines for Direct Land Application of Biosolids and Biosolids Products, 2002.)

For soil samples that complied with the Biosolid guidelines, a calculation was made to determine the maximum compost application limits. The “calculator” (see Figure 35) determined the maximum application rate of compost per hectare for each of the contaminants from farm specific soil and compost analysis. The rate which was the lowest was deemed the “limiting application rate”.

Soils from several properties were found to contain levels of either heavy metal (chromium or copper) or pesticide residues (dieldrin) that were above the guideline levels. These properties were then precluded from participating in the Demonstration Project, although interestingly it does not appear to preclude them from growing crops or using synthetic fertilisers with high levels of these metals. If the soil sample was found to comply with the allowable levels, the farm could participate in the project and use compost as directed.

On many occasions the contaminant producing the lowest limiting application rate was Dieldrin. There was, however, a process induced problem that often falsely identified Dieldrin as the limiting soil contaminant. This is because the laboratory analytical process can only detect down to 0.01ppm Dieldrin in soil and the maximum allowable concentration of Dieldrin in existing soil is 0.02ppm (Biosolid Guidelines 2002). To err on the side of caution when Dieldrin was not detected in a soil sample, the soil was reported as containing the analytical detection limit of 0.01ppm Dieldrin. This represents half the allowable limit and as such can lead to Dieldrin being the soil contaminant limiting compost application rates, without any actually being detected in the soil.

All soil samples collected for heavy metal and pesticide residue analysis were carried out according to the directions outlined in the Biosolid Guidelines. A composite soil sample was produced by sampling multiple sites within a given area to a depth of 15cm. This meant that, for the purpose of re-testing soils for heavy metals and pesticide residues before re-applying compost, it was assumed all compost applied was evenly distributed through the top 15cm of the soil profile even when compost was only applied to the soil surface.

The sites in this project were not established as scientifically replicated trials but as large un-replicated demonstration plots. This lack of replication has tended to highlight the variability of the background heavy metal level in the soils.

Figure 35 - Soil Heavy Metal & Pesticide Residue Calculator

Analyte	Maximum allowable Soil contaminant Conc'n (mg/kg)	Measured soil Contaminant Level (mg/kg)	Available Capacity of soil to assimilate contaminants	Measured Compost Contaminant Level	Allowable Application Rate (dry tonnes per Hectare	Tonne/ha Wet Weight
Arsenic (As)	20	5	15	2.2	13295.45	18465.9
Cadmium (Cd)	1	0.01	0.99	1.2	1608.75	2234.4
Chromium (Cr)	100	10	90	53	3311.32	4599.1
Copper (Cu)	100	5	95	94	1970.74	2737.1
Mercury (Hg)	1	0.02	0.98	0.24	7962.50	11059.0
Nickel (Ni)	60	5	55	20	5362.50	7447.9
Lead (Pb)	150	8	142	110	2517.27	3496.2
Zinc (Zn)	200	7	193	370	1017.16	1412.7
DDT/DDD/DDE	0.5	0.02	0.48	0.02	46800.00	65000.0
Aldrin	0.02	0.01	0.01	0.01	1950.00	2708.3
Dieldrin	0.02	0.01	0.01	0.05	390.00	541.7
Chlordane	0.02	0.01	0.01	0.01	1950.00	2708.3
Heptachlor	0.02	0.01	0.01	0.01	1950.00	2708.3
Hexachlorobenzene	0.02	0.01	0.01	0.01	1950.00	2708.3
Lindane	0.02	0.01	0.01	0.01	1950.00	2708.3
PCB's	0.3	0.1	0.2	0.2	1950.00	2708.3

Moisture content of compost (%)	28%
Soil Density (Tonnes/m^3)	1.3
Depth (m)	0.15
Soil Mass (t/ha)	1950

Maximum Application Rate (t/ha)	
DRY	WET
390.00	541.67

Nitrogen Limits

MR	0.1
Total N (mg/kg)	1000
Ammonium (mg/kg)	25
Nitrate+Nitrite (mg/kg)	7
Organic N (mg/ha)	975
Available Nitrogen (kg/ha)	109.5
Crop requirement (kg/ha)	100
N Limit (t/ha)	913.24

Soil heavy metal and pesticide residue testing was also carried out on "Control" areas where compost was not applied in order to establish a base or background soil contaminant level. All sampled areas were GPS referenced so repeat soil samples could be taken from exactly the same area of soil each time. It was found that soil samples taken over time from the same control areas tested differently in terms of heavy metal and pesticide residue content. This is thought to indicate variability in the distribution of these contaminants throughout the soil being tested and accuracy of analytical techniques. The implication of this is that variations in soil contaminant level in compost treated areas may not be only as a result of compost addition but may actually reflect variations in background levels. Consequently the addition of MSW compost had no clear impact on soil heavy metal and pesticide residue levels.

As a check for analysed levels it is possible to calculate the theoretical impact of adding MSW compost to soil. Table 10 below provides this calculation using a number of inputs, including soil sample depth, soil bulk density, soil and compost contaminant levels and compost application rate.

Table 11 - Theoretical calculation of topsoil contamination

Compost Contaminate	250	mg/kg
Soil density	1300	kg/m3
Top soil depth	150	mm
Compost spread rate	20	tonne/ha
Existing soil contaminate	10	mg/kg (ppm)
Existing contaminate /ha	19.5	kg/ha
Contaminate applied per ha	5	kg/ha
Total Contaminate/ha	24.5	kg/ha
Topsoil mass	1950000	kg/ha
Final Contaminate level - ppm (for top soil mass)	**12.56**	**mg/kg**

6.4 Logistics

6.4.1 Freight

The SMRC facility expects to produce approximately 25,000 tonnes of MSW compost per year on a year round basis with the amounts produced per week relatively uniform (ie non seasonal). The on-site facilities for the storage of finished compost hold approximately 800 tonnes. This high production rate and limited storage capability requires a very efficient compost distribution system with quick and constant deliveries to compost end users to avoid production delays.

In terms of delivering compost to end users there were several logistical issues that arose during the project. They included:

- road transport restrictions
- low bulk density of the compost (requirement for special large trailer and cleanliness)
- Limited opening times of SMRC facility

Both the location of a property requiring delivery of compost, and the entry/access to that property determined what sort of truck and trailer combination could be used for delivery. There are restrictions set by the Department of Transport governing which roads a road train (2 trailers) can operate on. If a property is located on or near a road that does not allow road-train traffic then the only option for delivery is a semi trailer type truck (1 trailer). The majority of broad-acre farms were able to utilize road trains for compost delivery as there was generally at least one approved route for a road train to take to reach the property, and the actual property had the required large areas for dumping of compost close to the trial site and road train turn-around areas. The majority of horticultural properties were closer to Perth and located on roads which did not allow road train traffic, and access to the trial site was limited due to the intensive use of the land and small access roads. This meant that most horticultural trial sites could only accept compost deliveries via a semi-trailer type truck.

In terms of compost delivery logistics, this has implications for both cost of compost delivery and the ability to deliver large amounts of compost in a set period of time. If a semi trailer is the only delivery method available there needs to be two round trips to the property to deliver the same amount of compost that a road train can deliver. It is important to note that although a road train carries twice the amount of compost compared to a semi trailer, it takes less than double the time to load with compost, drive to farm, unload at the farm and return for another compost pickup. A road train is also more cost effective per tonne of compost when compared to a semi trailer.

The bulk density of the compost ranges from approximately 450 – 600 kg per cubic metre depending on the moisture content. Compared to other farm inputs such as fertiliser or lime this is extremely light. The implication of this is that a fully loaded, normal volume semi-trailer can only carry approximately 20 tonnes of compost whilst a road train can carry 40 tonnes. To deliver larger amounts of compost (25-30 and 45-50 tonnes respectively) it is necessary to add devices called “hungry boards” to the top of the trailers to increase their volume and hence the amount of compost they can carry each load. One key logistical problem encountered during compost deliveries was the availability of the trailers with hungry boards from the freight contractors. The contractors rarely use them and the addition of the boards to existing trailers is a labour intensive task that requires several days notice. If a compost load is required urgently by an end user there may be a delay of several days before a properly equipped trailer is found or setup. This lack of specialised compost delivery trailers is not seen as a long term problem. Several contractors have expressed interest in permanently setting up this type of truck and trailer combination if the volumes of compost to be delivered can be guaranteed at an economically feasible total tonnage.

Another freight logistics problem encountered during the course of the project was the limited opening times of the SMRC facility. Given that the distances to end users are in the order of 100km or above, the turnaround time from loading to re-loading for a second delivery could be in the order of between 2 hours and 5-6 hours. The opening hours (for compost deliveries) of the facility were between 0730 and 1600 Monday to Friday. These hours limited the maximum number of compost deliveries in a day to some of the farthest properties to 2 per day. With one road train operating at maximum capacity this gives a total daily delivered weight of compost equal to approximately 90 tonnes. As the estimated maximum output of compost per day from the facility could be 180 tonnes per day this leaves a shortfall of 90 tonnes undelivered per day. Two options to overcome this could be to either a) extend the open hours during weekdays and/or open the facility for compost pickup on weekends to make up the weekly shortfall, and b) have more than one truck operating at any one particular time.

The best case scenario would be 2 road trains completing 2 deliveries each per day giving a total of approximately 180 tonnes of compost delivered. Whilst this may be possible when the SMRC is organising freight deliveries and able to book a road train/s for extended blocks of time, significant difficulties will arise if end users are paying for and organising their own freight carriers. End users will employ their locally available and trusted freight contractors, and wait for a back-loading opportunity to arise to minimise costs. These compost pickups will mostly be on an ad hoc basis and as such will cause significant compost distribution difficulties.

Horticultural properties are generally much closer to the compost source so freight turn-around times are not as significant but logistical issues arise due to the layout of most horticultural properties. Many horticultural properties are small in size (relative to broad-acre farms) and consist of many separate production blocks separated only by small gravel roads 3-5m wide. This makes the delivery of compost close to a specified area via a semi trailer a difficult task due to the inability of a truck to enter and exit a block without getting stuck or causing damage to the crops. To accept a compost delivery the end user often had to stockpile compost in a designated storage area convenient for truck access and arrange transport of the compost to the area of use themselves.

Photo 25 - SMRC loading facility

6.4.2 Storage

SMRC site storage

As mentioned in 5.4.1 the storage facility at the SMRC facility is limited to approximately 800 tonnes and there are numerous freight logistics problems that need to be overcome. As the maximum output of compost could reach 180 tonnes per day depending on the specification of the compost there is not much room for delays in distributing the compost off site. This storage problem highlights the fact that either a suitable large scale, off-site storage and distribution facility is found or their needs to be a dedicated compost distribution program with the ability to distribute large amounts of compost quickly to end users at minimal cost (ie freight subsidy).

On Farm storage

On farm open air storage of compost has been shown to be feasible for periods of over 12 months with little maintenance (see Photos 14 & 15 below). Some growers even commented that compost quality seemed to improve with extended storage time. No logistical problems with compost storage were encountered with most end users already having areas designated for storage of other farm inputs that could be used for compost.

Photo 26 & 27 - Compost quality maintained after 9 months of stockpiling in open air. Note the crusty surface with moisture underneath surface (Close-up on right)

6.4.3 Spreading and Application Rates

The demonstration trials highlighted several problems associated with spreading compost. In Broad-acre farming the spreading of sufficient quantities of compost with existing spreading machinery was a limiting factor. In horticultural operations, the application of compost into the tree or vine line was difficult with existing machinery and the availability of suitable spreading contractors was limiting.

Broad-acre

During the course of the initial farm inspections the project team ensured that project participants either owned, or had access to machinery capable of spreading large amounts of compost. The majority of participants already owned a "Multi-Spreader" machine for the purposes of spreading fertilizers and other soil amendments that could be used. Those who did not had access to a machine that could be borrowed, had a specialist spreading contractor they could employ to spread the compost.

The Multi-spreader machines are generally used to spread small amounts of high bulk density soil amendments over large areas of land, such as fertiliser at 100kg/ha with a bulk density of approximately 1000kg per cubic metre. The MSW compost supplied to farmers had a bulk density of approximately 500-600kg per cubic metre and the use of these machines to spread compost at the rates of 10t/ha and 20t/ha presented several logistical problems.

The maximum spreading capacity of the existing machines was found to be approximately 3t/ha of compost in a single pass. This meant that to achieve application rates of 10t/ha and 20t/ha the same area of land had to have approximately 3 and 7 spreading passes respectively. This high number of spreading passes creates problems of soil compaction and disturbance as the heavy tractor and machinery travel over the same area of land numerous times.

It also requires a significant time input on the part of the farmer and machinery running costs are inflated. On average it took a farmer 3-5 hours to spread both the 1ha trial blocks. After the initial spreading in 2004, all broad-acre farmers commented that they would need to modify their existing spreading machinery to be able to spread the compost in one or two passes maximum.

The time during which broad-acre farmers can integrate the spreading of compost into their farm management schedules (just prior to seeding) is extremely busy and the time available to them is limited. Several farmers modified their spreading machinery for the 2005 season or contracted specialised spreaders to establish the trial blocks. This meant they could spread the specified rate of compost in a significantly reduced time with less damage to the soil profile.

Photo 28 - Farmer spreading compost with existing Multi-spreader. These machines generally have a maximum spreading capacity of 3t/ha per pass.

Photo 29 - Spreading contractor applying compost using a high capacity spreader truck. This machine has a maximum spreading capacity of up to 10t/ha per pass.

The compost delivered to farms during the project varied in moisture content with each batch. The moisture content of the compost at the time of spreading was therefore dependant on the initial moisture content, and the time lag between compost delivery and spreading. Some batches of compost were left stored on farm for a number of weeks before spreading whilst some were spread almost immediately. Batches of compost that were lower in initial moisture content or that dried out during storage presented a problem when spreading. The low bulk density of the compost meant that if there was any wind on the day of spreading the amount of compost blown away from the target area could be significant. The associated compost dust clouds could also present an inhalation hazard for the machinery operator.

The trial results showed that compost applications of 20t/ha produced the highest yield response on average for the range of crops examined however wheat crops did not seem to respond to 20t/ha over and above 10t/ha compost. The reason for this observation is unknown at this point in time.

Photo 30 - Lower moisture content compost being spread. (Note dust)

Photo 31 - Higher moisture content compost being spread. (Note Compost fans out to full distance with minimal dust)

Horticulture
The spreading of compost on horticultural properties presented its own logistical problems. The major benefit of MSW compost in these horticultural systems was identified at the start of the demonstration project to be its performance as a mulch layer on the soil surface. For mulch to be effective it needs to be at least 50mm thick and spread in a narrow band either side of the tree (Buckerfield and Webster, 1996). Mulch acts as a physical barrier on top of the soil to prevent moisture loss, suppress weed growth and lower soil temperatures which are all beneficial to the horticultural crops (Whiting et al. 2005). Whilst many horticultural operators have their own fertiliser spreading machinery for use on the property, it was generally too small or not designed to spread compost in this manner.

Prior to MSW compost being produced, there has not been a readily available, inexpensive alternative to using existing high cost mulch materials. This has meant there are only a small number of specialised spreading machines being produced by machinery companies available to growers for this purpose. Significant delays were encountered by the growers participating in the project as they competed for the small number of machines available for hire from private contractors. It is envisaged that, if the production of MSW compost continues on in increasing quantities, market forces will drive the entry of new contractors into the industry and also encourage larger growers to invest in their own spreading machines specifically for the spreading of compost in this manner.

Several operators attempted to modify their existing machinery but the compost spreading results often failed to meet expectations. There were only two specialised side-throw compost spreaders available through spreading contractors in the South West of WA and their availability to the project participants was limited and necessitated a co-ordinated effort to transport the machines to growers at a convenient time.

Photo 32 - Side throw machine for banding compost down the tree line

Photo 33 - Side throw machine banding compost into tree line.

The compost has been shown to achieve the best results when used as a mulch layer spread down the tree/vine line. The use of the compost in this manner is safe and sustainable if the effective application rates in the applied area are below the rates specified in the soil and compost calculator (see Section 5.3 Heavy Metals and Pesticide Residues in soils).

For example, a 20mm thick mulch layer down the tree or vine line represents an effective application rate of 200 cubic metres (approximately 100t/ha wet wt) of compost per hectare in the applied area. Subsequent re-applications of compost to the same area require re-resting of the soil so that a new calculation can be determined, and the compost used at or below this rate.

6.5 Cost-benefit of compost use

The positive agronomic benefits of using compost in broad-acre and horticultural operations have been clearly demonstrated, however the economic viability of delivering and spreading large amounts of compost to these end users is the critical factor which will determine the future uptake of compost into these markets.

In this project compost was used as an addition to the farmer's regular program and its economic viability has been determined by subtracting the cost of freighting and spreading the compost from the increased income in the compost treated areas. If this figure is positive the use of compost is economically viable. Cost-benefit analysis of the type described was carried out on broad-acre and horticultural results over the two year project.

Freight costs are the largest component of the costs associated with using MSW compost. On broad-acre farms the freight costs represented approximately 80-90% of the total cost of using compost. Where compost was used on horticultural properties this proportion was less because of the closer proximity to the compost facility, but was still in the order of 50-60%. The increased financial returns arise from higher yields in broad-acre and horticultural crops from compost use.

Positive cost benefits were found on several properties.

6.5.1 Broad-acre cost-benefit

The compost application rates of 10t/ha and 20t/ha in 2004 were chosen because, in previous studies using similar material, 20t/ha was the lowest application rate that achieved a measurable beneficial effect on crop growth. This demonstration project examined application rates at or below this level because of the large distances to farms from the compost source and the associated high freight costs. If crop performance could be improved using lower rates of compost application, the economics of using MSW compost would become more viable.

The application rates of 10t/ha and 20t/ha produced significant yield increases in cereal crops in the 2004 growing season. These yield increases were up to 38% over the control areas but, particularly in wheat crops, there appeared to be no significant added benefit applying 20t/ha when compared to10t/ha. At the beginning of the 2005 growing season the decision was made to replace the 20t/ha treatment in wheat crops with a 3t/ha treatment. This rate was chosen as it represents a one pass spreading operation with existing machinery, and is a further refinement of lower application rates to examine the economics of using this material in a broad-acre situation.

The trial layouts of eight of the 2004 broad-acre trials were modified in 2005 to allow for an assessment of the residual benefits of compost use. These trials monitored the yield response of the 2005 crop to compost applications in 2004 only. These trials were established to see if the yield benefits (and increased financial returns) achieved over two cropping cycles could cover the cost of compost application in the first cropping cycle.

An economic analysis of the yields resulting from these treatment regimes was carried out on each of the broad-acre trials. These results are presented in full in the Appendix, but for the purposes of this discussion the best yield responses and associated economic analyses will be presented in the following case studies.

Photo 34 – Increased financial returns primarily come from increased crop yields

BN04 Case Study

BN04 was a property located approximately 171km North East of the SMRC facility, between Goomalling and Wongan Hills. In 2004 the demonstration trial was in wheat with compost applied at 10t/ha and 20t/ha. Yield increased over the control by 0.9 tonnes with 10t/ha compost and 1.1 tonnes with 20t/ha compost (34.6% and 42.3% respectively). This yield response was significantly higher than expected and reflected the moisture retention benefits compost application can bring in a dry year.

In 2005 the trial was located in a new paddock, also growing wheat. The compost was applied at 3t/ha and 10t/ha. Yield increased over the control by 0.1 tonnes with 3t/ha compost and 2 tonnes with 10t/ha compost (2.4% and 47.6% respectively). Any yield increase over and above 5-10% would be considered significant with any other input so the increases in yield with compost were exceptional. Broad-acre crops are very sensitive to input cost changes, with low margins per hectare and growers relying on planting large areas of land to produce adequate farm returns.

Treatment	Yield (t/ha)	
	2004 (Wheat)	2005 (Wheat*)
Control	2.6	4.2
3 t	-	4.3
10 t	3.5	6.2
20 t	3.7	-

Yield increases result in increased gross farmer returns. To calculate the net returns to the grower it is necessary to factor in the costs associated with both transporting the compost to the farm and spreading it at the designated rates.

Economic Factors	2004	2005
Silo Return ($/tonne)	$188	$188
Compost Freight ($/t/km)	$0.13	$0.13
Distance from SMRC (km)	171	171
Spreading Costs ($/tonne)	$3.00	$3.00

Compost freight costs are determined by the contract freight cost ($/t/km) multiplied by the distance to the farm (km) and the amount to be delivered. Total compost spreading costs are determined by the spreading cost ($/t) multiplied by the amount spread (t).

Assumptions:
Silo Return (income) is constant over the two year period
Freight costs are constant over the two year period (rate charged by contractor)
Spreading costs constant over two year period ($3/tonne as specified by grower)
Grain yield (t/ha) extrapolated from random quadrat (0.32 square metre) crop samples.

These costs then need to be subtracted from the gross revenue received through selling the harvested grain.

2004	Gross Revenue ($/ha)	Revenue Change ($/ha)	Increased Cost ($/ha)	Gross Margin Change ($/ha)
Control	494.44	-	-	-
10 t	654.24	159.80	252.30	-92.50
20 t	688.08	193.64	504.60	-310.96

2005	Gross Revenue ($/ha)	Revenue Change ($/ha)	Increased Cost ($/ha)	Gross Margin Change ($/ha)
Control	783.96	-	-	-
3 t	812.16	28.20	75.69	- 47.49
10 t	1158.08	374.12	252.30	121.82

The tables above show compost applications resulted in positive Gross Revenue Changes (ie. increased returns) in 2004 and 2005. In 2004 this increased return was not sufficient to cover the cost of the compost use (ie. negative Gross Margin Change).

In 2005, applying 10t/ha compost resulted in a 48% yield increase. This yield increase resulted in a +$374.12/ha revenue increase over the control. When the costs of compost use are subtracted from this return, Gross Margin Change was +$121.82/ha meaning that the costs of compost use were recouped and extra revenue gained to the value of $121.82 per hectare.

6.5.2 Economic benefit of residual compost on broad-acre farms

In eight of the original 21 broad-acre trials it was possible to monitor the 2005 crop without re-applying compost and it was here that there was a demonstrated benefit across 2 years. On these 8 farms the freight and spreading costs are incurred in the first year only are amortised over two years. Two of these sites showed yield increases where compost was applied in 2004 only (BE09 and BN03 Economic Analyses in appendix).

BN03 Case Study
Trial site BN03 was located in Bolgart approximately 136km from the SMRC facility. The crops grown were in wheat in 2004 and canola in 2005. The 2005 trial block layouts were modified to establish three treatment regimes: Compost applied in 2004 only, compost applied in 2004 and 2005, and compost applied in 2005 only.

Treatment	Yield (t/ha)	
	2004 (Wheat)	2005 (Canola)
Control	3.8	3.1
3 t - 2005	-	3.3
10 t - 2004	5.2	3.0
10 t - 2005	-	3.5
10 t -04/05	-	3.1
20 t - 2004	5.2	3.5
20 t - 2005	-	3.0
20 t - 04/05	-	2.9

The yield results above show substantial increases were achieved in 2004, whilst in 2005 there were only 3 of 7 blocks which yielded higher than the control (3t – 2005, 10t – 2005 and 20t – 2004). The economic analysis of these yield results requires the increased financial returns gained from higher yields to be measured against the costs associated with compost use.

Economic Factors	2004	2005
Silo Return ($/tonne)	$188	$320
Compost Freight ($/t/km)	$0.13	$0.13
Distance from SMRC (km)	136	136
Spreading Costs ($/tonne)	$3.00	$5.00

Compost freight costs are determined by the contract freight cost ($/t/km) multiplied by the distance to the farm (km) and the amount to be delivered. Total compost spreading costs are determined by the spreading cost ($/t) multiplied by the amount spread (t).

Assumptions:
Freight costs are constant over the two year period (rate charged by contractor)
Grain yield (t/ha) extrapolated from random quadrat (0.32 square metre) crop samples.

These costs then need to be subtracted from the gross revenue received through the selling the harvested grain.

Cost Benefit Analysis

2004	Gross Revenue ($/ha)	Revenue Change ($/ha)	Gross Margin Change ($/ha)
Control	718.16	-	-
10 t	975.72	257.56	50.76
20 t	985.12	266.96	-146.64

The 2004 results showed compost use was cost effective at 10t/ha.

2005	Gross Revenue ($/ha)	Revenue Change ($/ha)	Gross Margin Change ($/ha)
Control	1004.00	-	-
3 t - 2005	1044.00	40.00	-28.04
10 t - 2004	972.80	-31.20	-31.20
10 t - 2005	1108.00	104.00	-122.80
10 t -04/05	979.20	-24.80	-251.60
20 t - 2004	1120.00	116.00	116.00
20 t - 2005	944.00	-60.00	-513.60
20 t - 04/05	932.00	-72.00	-525.60

The 2005 results showed that the area treated with 20t compost in 2004 only (20t – 2004) was the only treatment with a positive gross margin change for that year.

An analysis of the two year combined gross margin changes is required to ascertain the cost effectiveness of compost use during the two year trial period.

2 Year Combined Analysis	Gross Margin Change ($/ha)
Control	-
10 t - 2004	19.56
10 t -04/05	-200.84
20 t - 2004	-30.64
20 t - 04/05	-672.24

The combined analysis showed that compost applied at 10t/ha in Year 1 (2004) resulted in an economically viable yield response over two cropping cycles. The Gross Margin Change over two years was +$19.56 per hectare.

This result was replicated at two other trial sites (see BE09 and BE10 Economic Analysis in Appendix).

Broad-acre crops are very sensitive to input costs because they are relatively low margin crops and farmers rely on economies of scale to produce viable farm returns. All broad-acre trial sites during the demonstration project used the standard, farmer prescribed synthetic fertiliser regime across all plots as the nutritional composition of the compost to be supplied was not certain at the time. Synthetic fertilisers are already a significant cost input for broad-acre farmers and the costs are rapidly rising. Now the nutritional content of the compost has been quantified, the opportunity exists for further trials to be done examining the viability of reducing synthetic fertiliser inputs to take into account the nutrients supplied by the compost applications (see Section 7.0 Recommendations).

6.5.3 Horticulture cost-benefit

The majority of suitable horticultural properties are located closer to the compost source (ie Perth metropolitan area), so freight costs are significantly less than broad-acre, which improves the economic viability of compost use. Horticultural crops are also of a much higher value than broad-acre crops (per unit land area) making them less sensitive to input costs. There is more financial margin for a horticultural producer to incorporate compost into a production system. As a result more horticultural properties had economic benefits of compost compared to broad-acre. In this project compost was used in addition to the regular fertiliser program. Further benefits will arise when it is integrated into the farmer's management program and other inputs are reduced.

The economic viability of compost use in horticulture can be illustrated by presenting economic analysis of case studies of compost use. The cost-benefit case studies selected for this report include a commercial wine grape vineyard, turf grass production and a citrus orchard.

Wine Grape Case Study
This vineyard is located near Dwellingup, 100km south of Perth. The demonstration trial was established in a small block of Shiraz grapevines in full production. The compost was applied as a banded layer down the vine line at thicknesses of 25mm and 50mm with control rows (no compost) separating the two treated areas.

Just prior to the 2005/2006 grape harvest (Year 2 of the project), the grape yields were recorded by the vineyard manager from each of these treated areas. There were large yield increases in both of the compost treated areas whilst maintaining grape quality (ie. constant fruit sugar contents).

Treatment	Yield (t/ha)
Control	6.9
25mm band	9.2
50mm band	12.2

As in the broad-acre example, the costs associated with compost use include the cost of freighting compost to the property and spreading costs. The financial benefits of compost use is the increased yield (t/ha) multiplied by the price received for the grapes ($/tonne).

Economic Factors	
Grape Price ($/tonne)	$1,500.00
Compost Freight ($/tonne)	$18.00
Distance from SMRC (km)	100
Spreading cost ($/ha)*	$250.00

	Gross Revenue ($/ha)	Revenue Change ($/ha)	Gross Margin Change ($/ha)
Control	10,350	-	-
25mm band	13,800	3,450	2,829
50mm band	18,300	7,950	6,958

Assumptions/Calculations:

Compost quantities are calculated on band width of 0.5 metres
3 metre vine row spacing
Compost bulk density of 500kg/cubic metre
25mm band = 20.6t compost/ha required
50mm band = 41.2t compost/ha required
Spreading cost ($/ha)* = cost of hiring compost spreader for one day. Actual $/ha will be less given that multiple hectares can be spread per day.
Yield (t/ha) extrapolated from kg/vine data supplied by grower (1,650 vines/ha)
Grape Price ($/t) = actual price received

The economic viability of using MSW compost in this vineyard is clearly demonstrated by the increased profit (Gross Margin Change) of $2,829/ha for the 25mm band and $6,958/ha for the 50mm band.

Young Citrus Case Study
Where demonstration trials were carried out on young tree or vine crops not in full production, the benefits of compost use were demonstrated in higher vegetative growth rates. As young trees or vines may take several years to reach a growth stage where they produce an economically viable crop, any input that can accelerate plant development and lead to earlier cropping will significantly alter the economics of growing that crop.

Young citrus trees take 8 years to produce a mature crop income (Gartrell, 2003). The demonstration trial results showed that stem diameter growth could be increased by up to 30% over a 2 year period in young trees or vines when compost was applied as a 50mm deep layer. It is reasonable to assume that this result could be extrapolated into faster overall tree vegetative growth and that this faster growth could lead to the citrus trees approaching full fruit production levels up to one year earlier than normal (Foord 2006, personal communication).

The normal production schedule can be summarised as follows:

Year	0	1	2	3	4	5	6	7	8
Yield (t/ha)	0	0	0	0	2	8	30	45	45
Income ($/ha)	0	0	0	0	562	2670	10,540	21,079	25,295

The Present Value of these cash flows (with a 7% discount rate) is $37,138.71 per hectare. The Internal Rate of Return is 17.52% and Positive Cash Flow is achieved after 9 years (Gartrell, 2003).

With accelerated growth and associated earlier production due to compost use the production schedule is as follows:

Year	0	1	2	3	4	5	6	7	8
Yield (t/ha)	0	0	0	2	8	30	45	45	45
Income ($/ha)	0	0	0	562	2670	10540	21079	25295	25295

The Present Value of these cash flows is $52,544.84 per hectare. The Internal Rate of Return is 21.36% and Positive Cash Flow is achieved after 7.5 years (Foord 2006, personal communication, based on Gartrell 2003 economic model).

Assumptions/Calculations - Compost freight and application costs of $900/ha incorporated into modified cash flow schedule in years 0 and 3 to reflect two compost applications to achieve accelerated growth (at 80 cubic metres compost/ha, 100km from compost source). All other costs held constant

The economic viability of compost use is clearly demonstrated on this young citrus farm, with increased cash flow of $15,406.13 per hectare over the 8 year period, an increased Internal Rate of Return and a shorter time to achieve positive cash flow.

Turf grass Case Study
The economic viability of compost use in turf grass production can be demonstrated by examining the cost savings achieved from reduced synthetic fertiliser use when compost is applied post harvest. One of the demonstration project participants growing turf grass reported they were able to reduce the application of nitrogen (as urea) by as much as 50% in areas where compost had been spread (broadcast at 40t/ha) after harvest. This fertiliser saving alone can be demonstrated to cover the cost of compost applications.

Economic Factors
Urea cost = $129.04 per hectare (150kg/ha @ $34.41 per 40kg bag)
Compost cost = $350 per hectare (40t delivered 20km to farm)
Estimates are based on each crop

Before compost applications commenced on this property, after each harvest urea was applied at 150kg/ha on a fortnightly basis (for 4 months for each crop). After compost application, this has been reduced to 150kg/ha on a monthly basis (for 4 months for each crop) which represents a 50% fertiliser cost saving.

With compost	$ per application	$ per Crop
Urea application cost ($/ha)	129.04	516.16
Compost cost ($/ha)	350.00	350.00
Total cost ($/ha)		**$866.16**
Without compost		
Urea application cost ($/ha)	129.04	1,032.32
compost cost ($/ha)	0.00	0.00
Total cost ($/ha)		**$1,032.32**

The addition of 40t/ha of compost has resulted in a saving of $116.16 per hectare per crop in urea costs alone. This saving would be larger if other synthetic fertiliser savings, water use efficiency benefits and increased crop growth rates were quantified and factored into the economic analysis.

Fruit Quality Improvements
There were difficulties in assessing the economics of compost use on some horticulture farms because the benefits gained do not necessarily result in immediate, measurable price increases. An example of this was found in stone-fruit production where project participants reported improved evenness of fruit ripening potentially resulting in fewer harvesting operations. The post harvest fruit handling characteristics were also improved as the fruit was noticeably firmer (grower observation). This reduces the chance of fruit

damage when handled lowering wholesale and retail wastage rates, but it may not result in an increased price received for this fruit.

6.5.4 Summary

These case studies have demonstrated the economic viability of compost use in both broad-acre and horticultural operations. The economics of compost use in horticulture mean that this market sector has the potential to absorb large amounts of compost over time with end users paying freight costs. Whilst the economics of compost use in broad-acre operations has been demonstrated here, freight costs represent a significant barrier to further uptake, especially in areas outside of the 100-150km radius from Perth examined in this project. For this reason there needs to be an examination of methods to decrease freight cost to broad-acre end users. Two methods to achieve this are the provision of freight subsidies or the commercialisation of pelletised compost.

6.6 Pellet Program

During the 2004 growing season discussions with broad-acre farmers highlighted the need for a compost product that was easier to freight and could be used at lower application rates. A small quantity of compost was pelleted on the basis that this would improve the practicality and cost-effectiveness of using MSW compost on broad-acre farms.

Pelleted compost has several practical advantages over bulk compost:

- The bulk density of the pellets are higher (approx 850kg/m^3 compared to bulk compost of 500kg/m^3) allowing more compost to be freighted per unit volume. This increases the distances compost can be freighted economically.
- The application rates in broad-acre systems drop from up to 20 tonnes of bulk compost broadcast per hectare to the order of 100 – 200kg/ha pelletised compost placed precisely at seeding.
- The compost is applied using existing sowing machinery at seeding, which also eliminates the separate spreading operation required with bulk compost. It places the compost pellet under the soil surface next to the seed for more immediate effect (compost pellets could also be applied using conventional broadcasting machinery).

Pelletising compost requires specialised machinery and a high degree of knowledge concerning the physical properties of the source material and its behaviour under pressure and heat. In simplified terms, pellets are produced by forcing the source material, in this case MSW compost, through holes in a die to form a cylindrical ribbon of compressed material which will hold its shape and can be cut off at specified lengths to produce a pellet.

Significant difficulties were encountered locating a facility in WA that was capable of producing pellets from MSW compost. The stockfeed industry was reluctant to put MSW compost through their production systems because of the potential for contamination of machinery and the delays to their own production.

Commercial producers of pelletised organic fertiliser ran trial batches, but experienced blocking of the pellet dies, due to the physical properties of MSW compost, which prohibited the pellet operation continuing. After consultation with these companies, a low compression die for use in a small pelleting machine that had previously been trialled, was imported and 300kg of pelletised compost produced.

Three pelleted compost trials were conducted, however the production delays meant that pellets could not be trialled adequately in the field during the winter of 2005. Two on-farm demonstration trials failed to produce any meaningful results whilst a replicated pot trial at UWA produced some valuable indications of compost pellet performance.

The UWA pot trial showed significant improvements in crop growth using 100kg/ha of pellets with full and half fertiliser applications. However, further increasing the rate of pellet use caused declines in crop growth. It has been suggested that this effect may have been caused by more intensive decomposition of organic matter (Murphy et al. 1998) or nitrogen immobilisation as a function of the C:N ration of the organic matter provided (Bhupinderpal-Singh et al. 2004; McNeill et al. 1998; Neve et al. 2003).

Root growth was at a maximum at full inorganic fertilisation with 3t/ha of unpelleted compost, which suggests that any potential nitrogen immobilisation caused by intensive microbial activity during decomposition of organic matter was remedied by high application of nitrogen in the full rate of inorganic fertilisation (Rengel 2005).

This effect wasn't repeated with higher rates of pellet use, which suggests manipulation of the pelleting process and/or the addition of synthetic fertiliser to the compost before pelleting may increase the suitability of the pelleted compost for use in agricultural or horticultural production systems (Rengel, 2005).

From a market development point of view this pot trial result is extremely valuable as the increased crop growth was achieved using a material (compost pellets) that is more cost-effective to use.

Given the results from the pot trials it was decided to boost the nitrogen level in compost pellets with synthetic fertilizer (UAN, a 44% nitrogen only liquid fertiliser) for the 2006 program. 800kg of these high nitrogen compost pellets plus nearly 2 tonne of the unamended pellets were produced in April/May 2006 and distributed to selected farm participants for further demonstration trials during the 2006 season.

Some of the material has been allocated to a Muresk honours student examining the effect of pelleted compost on cereal growth. The remainder will be used in demonstration trials on selected farms (5) recruited from past demonstration project participants. All 2006 trials will examine the growth response of broad-acre crops to additions of 50kg/ha and 100kg/ha compost pellets (with and without extra nitrogen) incorporated into the soil at the time of seeding.

Subject to the results from the 2006 pellet program, the feasibility of producing pelleted MSW compost on a commercial scale should be explored. This is supported by the interest in pelleted MSW compost by farmers. 82% of respondents to the “Farmer Response” survey, expressed an interest in trialling the use of pelletised MSW compost in both broad-acre and horticulture operations.

6.7 Market Potential

The SMRC’s Regional Resource Recovery Centre is the first of several MSW compost sites to be commissioned around Perth. At full production the facility produces 80-100 tonnes of compost per day or 20-30,000 tonnes per year.

It has been estimated there could be 300,000 tonnes of MSW based compost in the Perth metropolitan area if all the possible compost sites are established. The large quantity of compost potentially produced by these facilities (the SMRC facility is only 10% of total) far out strips the ability of the current domestic market to absorb and there is a need to use this material to develop the fledgling agricultural compost market.

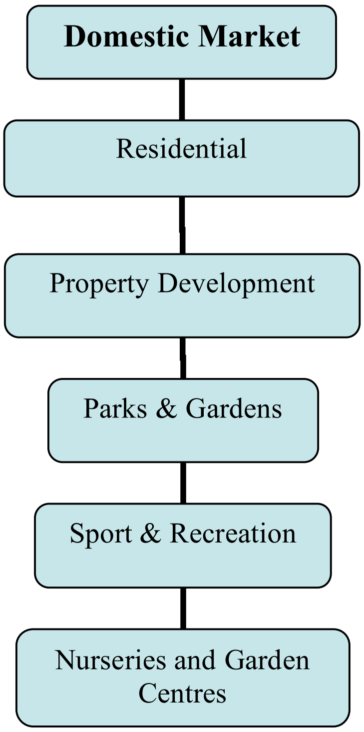
At an average usage rate of 10 tonnes per hectare it would require 3,000 hectares of crop to utilise the SMRC compost and 30,000ha to utilise all potential MSW compost produced from Perth municipal solid waste.

State of the Industry
The compost industry is at different stages of development, depending on the market segment, and each segment needs to be considered for this discussion.

- Domestic/landscape market for compost and mulch, including the soil blending industry,
- Commercial crop production, and
- Land rehabilitation

Domestic Market
The current market for compost is primarily for domestic and landscaping use in the metropolitan area. The uses include segments of landscaping for residential and property development; state and local government parks and gardens; sport & recreation; nurseries and garden centres.

Figure 36 - Domestic market segments for compost



This segment is considered a mature market that is almost fully developed. There are a number of compost manufacturers competing in this segment, where production capacity is thought to exceed demand for compost and mulch. Increasing supply from a new source will potentially put downward pressure on prices unless it is managed carefully.

The domestic market segment requires a C1 standard compost (unrestricted use) and MSW compost may need to be blended with other compost if it does not meet this standard.

Compost for Agriculture

Today, most farmers in Western Australia are using synthetic fertilisers to feed nutrients into their crops. Compost, however, can be thought of as a source of "slow release" nutrients and because of its soil moisture and fertiliser holding benefits it also offers the potential of long term solutions for sustainable soil management which fertilisers alone are unable to achieve.

The marketing of compost to farmers needs to not only concentrate on the immediate soil and crop performance benefits that can be gained, but also on the importance of integrating such materials into existing farming practices to build up soil health and ensure long term farming sustainability. Farmers are acutely aware that previous soil management practices have led to a depletion of soil nutrients and organic matter and are looking for a way to redress these problems. MSW Compost will be the most cost-effective off-farm source of organic matter available to them and should be marketed as such.

Compost of C2 standard is restricted for agricultural use in its original form, which limits the market to broad-acre and horticultural sectors that are largely based outside the metropolitan area. Transportation to these markets is the largest single cost, apart from production costs, for all compost suppliers and users.

Table 12 - Agricultural market potential

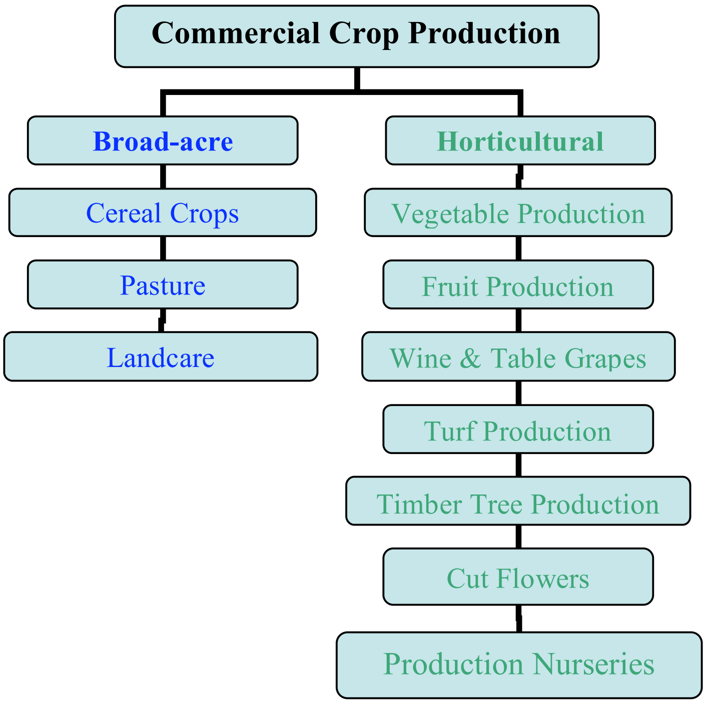
Market Segment	Target Market	Area (ha)		Gross Farm Income/ha	Compost Use t/ha	MSW Market
		Compost Region	WA	WA		Potential 000's tonne
Commercial Crop Production - Broad-acre (Unirrigated)	Barley	353,000	909,300	329	3	211.8
	Oats	207,200	316,300	224	3	124.3
	Triticale	15,900	25,900	197	3	9.5
	Wheat	2,980,900	4,263,700	380	3	1,745.3
	Chick Peas	25,100	42,600	336	3	15.0
	Faba Beans	20,600	21,600	212	3	12.4
	Field Peas	19,900	26,300	228	3	11.9
	Lupins	629,100	1,080,400	179	3	377.5
	Canola	38,500	106,500	770	3	23.1
	Hay	64,100	103,700	400	3	38.5
	Lucerne	5,100	5,400	578	3	3.1
	Other Pasture	66,000	86,400	700	3	n/a
Total Unirrigated Crops		**4,425,400**	**6,988,100**			**2,572.4**
Commercial Crop Production - Horticulture (Irrigated)	Fruit & Nuts	4,064	4,756	24,180	40	162.5
	Grape Vines	2,208	2,654	11,002	40	88.3
	Pasture	9,920	10,592	1,150	n/a	n/a
	Vegetables	5,226	7,336	24,714	40	209.0
	Olive Trees	3,264	4,143	10,000	40	130.5
	Nurseries	486	545	n/a	n/a	n/a
	Cut Flowers	762	1,093	67,000	20	15.2
	Turf (Cultivated)	392	398	75,000	60	23.5
Total Irrigated Crops		**26,322**	**31,517**			**629.2**

Notes:
Based on ABS statistics. Industry estimates have been included for turf, olive, hay and vegetable production.
No figures are available for commercial timber production.
MSW figures include broad-acre area in the Midlands and Upper Great Southern statistical division.
Broad-acre potential volumes are calculated on 20% of statistical division crop area.

Most of the broad-acre area listed in Table 12 will be beyond the viable distance for transport and potential for this market segment has been discounted accordingly. Subject to economic viability, the market potential for MSW compost in horticulture is 629,000t per year and in broad-acre farming it is 2.5million tonnes per year. This is far higher than the potential annual production from all proposed composting facilities of 300,000t.

Horticultural markets include production nurseries, market gardens, fruit production, wine and table grapes, cut flowers, timber tree production and turf production. Agricultural markets include broad-acre crop production and Land-care projects.

Figure 37 - Agricultural and Horticultural Market Segments



The horticultural sector should be the initial target market for MSW compost. Horticulturists have the physical and financial capacity to consume large amounts of compost on a year round basis, and many of them are close to the metropolitan area resulting in lower freight costs.

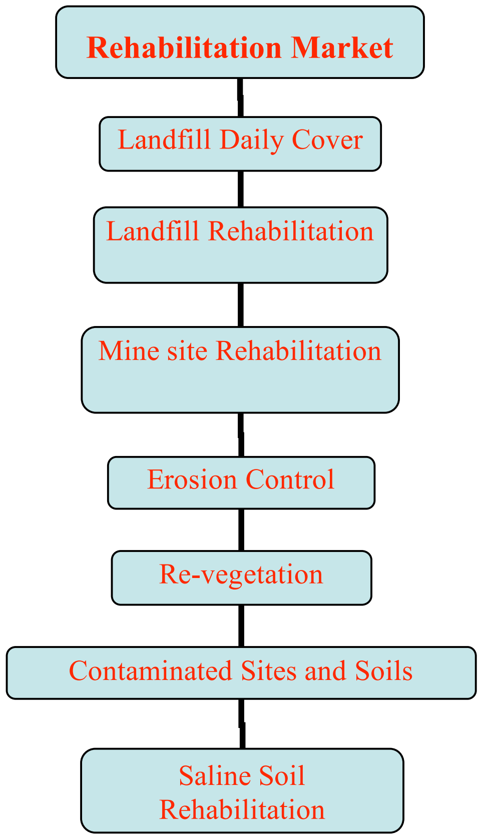
Horticultural crops are more intensive in their land use and generate greater gross revenues per unit of land area due to the high value of the crops produced. This means there are greater potential gross margins per unit area available in these operations. These crops are produced with a higher input cost base (eg. labour, fertiliser, chemicals) but the economics are more favourable to increases in input costs such as the addition of MSW compost.

Horticultural crops such as fruit trees, olives or grape vines are perennial in nature but, even though they only produce one crop per year, the application of compost into the system can occur at any time of the year. This is in contrast with an annual broad-acre operation where the compost can only feasibly be applied within 2 months of seeding each year’s crop. This flexibility in the timing of compost application allows the horticultural sector to take delivery of compost throughout the year.

Within the horticultural sector, turf grass operations could be one of the biggest consumers of MSW compost because they produce two or three crops per year and compost is applied before the commencement of each crop.

Land Rehabilitation
Rehabilitation projects provide both ongoing and opportunistic type marketing opportunities. These opportunities include landfill daily cover, landfill rehabilitation, mine site rehabilitation, erosion control, revegetation, saline soil rehabilitation, contaminated sites & soils. These projects are looking for low cost inputs and provide an opportunity to utilise MSW compost on an opportunistic basis. Market size estimates are not available for this segment.

Figure 38 - Land Rehabilitation Market Segments



Supply reliability and seasonality
To gain market confidence the compost needs to be available in constant quantities all year round and be of a consistent quality, especially in terms of maturity and moisture content. Extreme care must be taken to ensure non C2 compliant compost batches do not enter the market as the damage to the market perceptions of the product would be significant.

Different compost maturities and moisture contents can have a significant effect on the visual appearance, handling properties and odour of the compost. Ensuring these characteristics are kept consistent will allow the market to develop a confidence in a uniform compost quality.

As the compost has been shown to be stable when stored in the open air for long periods of time (over 12 months) it is possible for compost deliveries to both broad-acre farms and horticultural properties to take place all year round. The timing of compost application will be seasonal and at the end users discretion. There may be an increased demand for deliveries from broad-acre end users after harvest (Dec – Jan) as trucks delivering grain from the farm to Perth become available for back-loading. Horticultural properties will primarily use the compost as mulch and are able to receive and apply the compost in this manner any time of the year.

The reliability of supply in terms of both quantity and quality are essential for the successful market development of this product. During the course of the Market Development Project there have been several issues regarding the reliability of supply.

Quantity

In 2004 the 46 demonstration project participants received large amounts of compost ranging from 50 to 500 tonnes each for trial purposes. The project participants used all the finished compost produced at the SMRC facility and those who wanted more compost were accommodated, with several farmers offering to pick up the freight costs themselves. During the course of the Field Days the availability of compost was made widely known and interest was high.

In 2005 the compost production facility experienced a high number of mechanical problems which severely limited finished compost availability. Compost had to be rationed amongst the participants, with the minimum amount required to complete trial establishment being supplied before extra material could be made available. There were numerous times when no compost was available for long periods of time. This had several deleterious effects on the market development of this material.

Several participants were left with not enough compost to justify the hiring of specialised spreading equipment. This meant spreading was delayed beyond the optimal time and the full benefits of compost could not be achieved. Comments also arose questioning whether the longer term viability of the plant was certain and some growers expressed concerns about gearing up to accept and spread large amounts of compost if availability could not be guaranteed to some degree.

There were also a number of people who went to the expense of obtaining soil tests to clear them for use of MSW compost without being able to pick up any material due to halts in production

Quality

There is a need to inform end users that MSW compost may contain contaminants, however, no matter how high the quality there will be an emotional human response when dealing with a product made from municipal solid waste. An attitude still exists in the market that MSW compost is a “waste product”, and as such it is essential the quality of all finished product released to the public is of the highest possible standard. Any release of poor quality product will reinforce these negative perceptions and market confidence will be extremely hard to regain.

Participants in this project highlighted that contaminants potentially found in MSW compost are a significant limitation to its further use. These reductions may be achieved by examining further source separation techniques or additional physical processing.

There are currently two major markets which have not yet been exposed to MSW compost, commercial vegetable crops and domestic/public parks and gardens. Any improvements in compost quality will aid acceptance by both of these markets

Commercial vegetable crops represent a significant potential market for low cost compost. Vegetable crop rotations are short resulting in opportunities for multiple applications of compost each year. There are approximately 5,000 ha of vegetable production in relatively close proximity to the Perth metropolitan area and the majority of farms have a significant need for soil amendments such as compost. Producing compost of a standard suitable for vegetable production will increase the potential market for compost in horticulture by nearly 50%.

7. Recommendations

Government foresight and financial support has enabled the SMRC and Organic Farming Systems to successfully complete the initial stages of market development for MSW compost with this Demonstration Project. With continued funding we can support the following recommendations.

To encourage more widespread use of compost within the farming community we recommend the following:

1. Support farmers to integrate compost into their farm management practices. This can be achieved by carefully reducing synthetic fertiliser inputs with expert advice.
2. Continue to promote the results of this project amongst the farming community by seeking support to present the report's findings at future conferences, farmer field days and workshops.
3. Training of agricultural consultants in the benefit and usage of compost systems
4. Exploring the viability of freight subsidies, economies of scale and innovative logistics solutions as farmers believe freight costs are the largest constraint on the use of compost.
5. Further trials need to be conducted to examine the response of broad-acre crops to pelleted compost.
6. Exploring methods to reduce application rates by precision placement of compost; eg sub-soil banding in trees and vines.
7. Further monitoring of existing trial plots for 1-3 years to assess the ongoing residual benefit gained from using compost. This will refine the cost-benefit analysis to underpin the economic viability of using MSW compost.
8. Concentrating bulk compost marketing on the horticultural sector which has shorter freight distances, higher value crops.
9. Establishing trials to examine the effectiveness of MSW compost in ameliorating saline agricultural land.
10. Reducing the chemical and physical contaminant levels in MSW compost via engineering solutions in manufacturing facilities, education of waste generators and source separation of waste.

Recommendations for farmers using MSW compost
As part of integrating compost into a total farm management system there are a few basic compost use methods that should be implemented.

Where practical, applied compost should be incorporated (cultivated) into the soil to maximise benefits and minimise non-wetting characteristics that may occur after continued exposure of organic matter to hot dry conditions.

In broad-acre crops, compost is recommended to be broadcast up to 20 tonnes per hectare (wet weight). In wheat, compost applications can be reduced to a maximum of 10 tonnes per hectare as there appears to be little additional benefit gained from exceeding this rate. Ideally stubble should be retained and compost broadcast as close as possible to seeding. Incorporation can be achieved either by a separate operation prior to seeding (eg. harrows) or at seeding using standard seeding equipment.

In horticultural situations, compost can be applied either in the tree/vine row or broadcast over the whole soil surface. Where it is applied as a banded layer the effective application rate should be below the maximum calculated from the soil and compost residues calculator. In tree and vine crops, incorporation can be achieved in the inter-row spaces when seeding cover crops. Applications of compost to turf grass should be soon after harvest so the new grass will grow over the compost applied to the soil surface.

8. Glossary:

Actinomyces:	Soil inhabiting bacteria that feed on dead organic matter and can become disease producing plant parasites.
Aerobic:anaerobic ratio:	A measure of the number of aerobic bacteria (beneficial) relative to the number of anaerobic bacteria (non beneficial) found in a soil sample. A ratio of 10:1 is indicative of a healthy soil bacterial population.
Back-loading:	The act of utilizing an otherwise empty freight truck either on its journey to or from a destination. Back-loading charge rates are usually lower than a standard one way delivery.
Buffering capacity:	The capacity of a soil to limit the changes in pH or nutrient content caused by external factors (eg. water or fertiliser).
Combine:	A type of seeding machinery that disturbs the soil profile to a large degree by turning over the soil and incorporates (combines) seed or fertiliser in one activity.
Composite soil sample:	Soil is collected from a number of sites (15 in this project) within a paddock and then combined into one sample for analysis.
Dry-land crops	Crops grown without irrigation, only with rainfall
Dry weight:	The weight of an oven dried plant or soil sample of known volume or quantity. Dry weights are calculated to remove the influence of sample moisture content.
Electrical conductivity (EC):	The ability of a soil solution sample to conduct electricity. EC is a measure of the amount of electrical charge carrying ions in a solution and is generally used to describe the salinity of a sample.
Grain/seed quality:	The moisture content, protein content, oil content, grain size or screening percentages (shrivelled grain) of a sample of grain or seed.
Gross margin:	The difference between the revenue received from an area of land (Yield x $/tonne received for crop) and the costs incurred in producing that crop.

Humus:	Soil colloidal particle; dark sticky organic matter; it can be thought of as partially decomposed soil organic matter
Knife-points:	Specialized crop seeding equipment that is used to minimise the disruption to the soil profile when seeding a crop; acts like a knife when cutting through the soil.
Macronutrient:	A nutrient needed in large quantities for normal healthy plant growth. Examples include nitrogen, carbon, phosphorous, potassium, calcium, sulphur and magnesium.
Micronutrient:	A nutrient required in only small quantities for normal healthy plant growth. Examples include manganese, boron, copper, iron and zinc.
Minimum tillage:	A soil management and crop seeding technique which aims to minimise the physical damage to the soil profile. (Knifepoint seeding equipment is used as part of this technique).
Municipal Solid Waste: (MSW)	The refuse/waste stream generated from households and businesses. In this case it does not include the green waste or recycling fractions of the waste stream.
MSW compost:	Quality Assured compost made from the municipal solid waste (MSW) stream to comply with Australian Standards.
Multi spreader:	A piece of farm machinery capable of being towed behind a tractor that has a power driven floor and rotating discs to spread compost, fertiliser, lime or other soil amendments over large areas of ground.
Organic carbon:	This is a measurement of organic matter in the soil; ie. the carbon residue primarily retained in the soil as humus &/or soil micro-organisms.
Pelletised compost:	Compost which has been mechanically compressed and shaped into small pellets (approximately 5mm diameter x 5-8mm long) to increase the compost bulk density (weight per unit volume).
pH:	A measure of the acidity or alkalinity of a solution. Values less than 7 are acidic, values greater than 7 are alkaline (7 is neutral).

Soil Moisture:	The amount of water retained in a given volume of soil.
Tillering:	The process where a cereal plant which has initially produced one stem starts to produce additional stems (called tillers) at a certain growth point. Increased tillering can lead to increased yield if new tillers produce grain heads.
Trace element:	See micro nutrient
Tynes:	The part of the seeding machinery that digs into the soil so that the seed and fertiliser can be placed below the soil surface.
Veraison	The onset of grape ripening characterised by the berry increasing in size, softening and rapidly accumulating sugar. Veraison is a time when the grapevines water requirements from the soil increases dramatically and berries change colour.

9. References and Further Reading:

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