Recycled Organics Unit

Recycled Organics Products in Intensive Agriculture

Volume 1 – Introduction

A review of recycled organics products application field trials in intensive agriculture in Australia

2007

Second Edition

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Second Edition.
First Published 2003.

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Department of
Environment and Conservation (NSW)

THE UNIVERSITY OF
NEW SOUTH WALES
SYDNEY · AUSTRALIA

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Acknowledgement

The Recycled Organics Unit (ROU) would like to thank Department of Environment and Conservation (NSW) for providing funding to make this research project possible.

Many persons and organisations across Australia also have made their published and unpublished information and reports available to be included in this review. They are graciously thanked for their contributions.

The Recycled Organics Unit (ROU) would like to thank Dr Kevin Wilkinson, Department of Primary Industries, Victoria for reviewing this document and providing comments.

Executive Summary

A market study performed by the NSW Waste Boards in 1999 identified significant potential exists for the use of recycled organics (RO) products in intensive agriculture. The existing market for RO products to the emerging intensive agriculture market in NSW is very small. Affordability, product quality and performance have been identified as key issues in intensive agriculture market in NSW for recycled organics products (NSW Waste Boards, 1999; Recycled Organics Unit, 2002).

In order to develop markets in intensive agriculture for RO products, resources should be invested into specifying RO products that offer maximum cost/benefit advantage for particular applications, then demonstrating the performance and cost/benefits of these products to support market development. These market segments should be strategically selected using criteria that target the maximum recovery of organic "waste" materials, financial viability and/or environmental benefits. Such criteria may include distance to market from metropolitan centres; value of market potential; market capacity to pay; and need for RO products in the intensive agriculture production system. In this context, previous studies have demonstrated that the viticulture, fruit and orchard production and market gardening market segments warrant initial exploration given their suitability and the potential to benefit from the use of RO products (NSW Waste Boards, 1999). Before this can occur, gap analysis is required to indentify remaining gaps in information with regard to the performance of RO products in these market segments. Until this is performed, the application of resources to demonstrate the performance and cost/benefits of generic RO products in intensive agriculture applications is of very limited value to either government or the private sector.

Quantifying the performance of various RO products is one of the most significant barriers to the correct agricultural application of RO product because performance varies across various regions and states due to varying product charateristics, environmental conditions, crops, varieties and management systems. Performance based products tailored match to the specific needs of intensive agriculture applications, with a minimum level of quality is one contributing strategy proposed to overcome barriers to the emerging intensive agriculture markets (Recycled Organics Unit, 2002). Product standards will provide assurance that the application specific RO products are produced to a consistent quality to meet the performance and value expectations of the user.

The majority of land degradation in Australia is related to low organic matter levels in soils. An increase in organic matter can directly and indirectly correct land degradation problems such as sodicity, soil structure decline, and erosion. Where RO products are imported to increase organic matter, quantitative and qualitative benefits will be dependent upon the specific characteristics of the RO product used, the application rate, the method and timelines of application, environmental conditions, and post application management practices.

The application of RO products in intensive agriculture has been studied in Australia via a range of applied trials over the last ten years using various composted products. However, most of this research has not been published or peer reviewed and is not readily accessible. Therefore the objectives of this report were to obtain and review all available relevant project reports, publications and articles across a range of potential intensive agriculture markets. Generic results from generic product application will not provide consistent, reliable, nor optimum cost/benefit information, and are unlikely to overcome the documented affordability.

Section 1 How to Use the Report

1.1 Objectives of the report

The NSW Waste Boards market study carried out in 1999 identified significant potential exists for the use of recycled organics (RO) products in intensive agriculture. The existing market for RO products in intensive agriculture market in NSW is very small. Creation of demand in this market requires knowledge of performance benefits of RO products in the market segments (e.g. viticulture, fruit and orchard production, market gardening, etc.) and evaluation and development of performance based product specifications to meet needs of these markets (Recycled Organics Unit, 2002).

The application of RO products in intensive agriculture has been studied in Australia via a range of applied trials over last ten years using various composted products. However, most of this research has not been published or peer reviewed and is not readily accessible. Therefore the objectives of this report were to obtain and review all available relevant project reports, publications and articles across a range of potential intensive agriculture markets to:

- Establish baseline performance data for specific intensive agriculture applications within the context of environmental factors and farm management systems;
- Review the methodology of previous trials, document key experimental design issues for applied field trials and to prioritise relevant monitoring parameters for the purpose of establishing the performance benefits and cost-benefit of application of RO products;
- Identify gaps in available data, thereby informing and prioritising future applied product application trials; and
- Provide baseline information to support the future development of performance-based RO product standards and associated application guidelines for priority intensive agriculture market segments.

1.2 Scope

The report reviews relevant and credible publications addressing the application of RO products in viticulture, fruit and orchard production, and market gardening segments of the intensive agriculture market. This report does not address on nurseries, cutflower, and turf market segments of the intensive agriculture market. This report does not review articles from trade journals, it focuses on primary research reports from applied field trials.

Information reviewed will include (but not be limited to) studies conducted by Organic Waste Recycling Unit (OWRU), NSW Agriculture; Agriculture Victoria (Institute for Horticultural Development); Agriculture WA; CSIRO Land and Water; and SA EPA.

1.3 Who is the report for?

This report is for government policy makers who have involvement in the development of programs and initiatives to support the development of the recycled organics industry. Government support in this context aims to assist industry in maximising the diversion of compostable organic materials from waste stream, to beneficial and higher resource value applications.

This report is also for manufacturers of recycled organics products who invest in new product development and whose livelihood is dependent upon the sale of recycled organics products.

In particular, the report has been written for:

- Department of Environment and Conservation (NSW);
- Manufacturers and/or blenders of recycled organics products;
- Marketers of recycled organics products;
- Agriculture and Natural Resource departments of various State Governments;
- Waste educators;
- Industry consultants; and
- Relevant interstate and Commonwealth Government agencies.

1.4 How to use the report

The report is organised in four volumes.

Volume 1: Introduction

Volume 2: Viticulture

Volume 3: Fruit and orchard production

Volume 4: Market Gardening

The first volume details the objectives of the report, who this report is for, how to use the report, terminology and how to cite the report. Next it contains an introductory section, which firstly provides an overview of the structure of RO product markets, information on the documented potential of RO products in each market segment and demand potential that has still to be realised. Next it provides introduction to the previous research and development (R&D) programs using RO products in intensive agriculture and highlights gaps and limitations of such programs. Then it differentiates between scientific and demonstration trials and their role in creating behaviour change through product development and agricultural extension. The need for consolidated information on performance benefits for the purpose of accessing markets and developing products to meet market needs is then demonstrated. Finally this volume contains conclusions and recommendations.

The second, third and fourth volumes provide information on each of three intensive agriculture market segments viticulture, fruit and orchard production and market gardening respectively. Each volume provides firsly a brief description of the market segment and an overview of the farm management systems. An assessment of the context of applied field trials is then provided, and spectfic variables affecting performances such as climate, soil types, irrigation/non-irrigation, irrigation water quality, RO product type, RO product quality, RO application rate and method and experimental design are reported. Performance outcomes arising from the use of RO products in the specific market segment are listed under four categories: reduced risk of crop loss; increased revenue due to increased yield; reduced costs in farm management; and increased farm capital value. The review identifies the gaps and limitations of existing studies, each volume contains conclusions, recommendations including recommends R & D priorities and methodology for field trials specific to each market segment. Finally each volume contains references, glossary and appendices.

1.5 Terminology

Terms used throughout this report have been officially adopted by the NSW Waste Boards in July 2000 in the form of the Recycled Organics Dictionary and Thesaurus: Standard terminology for the recycled organics sector (Recycled Organics Unit, 2002a). This document is freely downloadable from http://www.rolibrary.com

Where possible, nationally accepted terms have been used in these reports. Definitions of the key terms in the text are provided in the glossary of each report.

1.6 How to cite the report

This report shall be cited in the following manner:

Recycled Organics Unit (2003). *Recycled Organics Products In Intensive Agriculture Volume 1-Introduction: A Review of Recycled Organics Products Application Field Trials in Intensive Agriculture in Australia*. Recycled Organics Unit, internet publication: www.recycledorganics.com

Section 2 Introduction

2.1 The recycled organics market structure

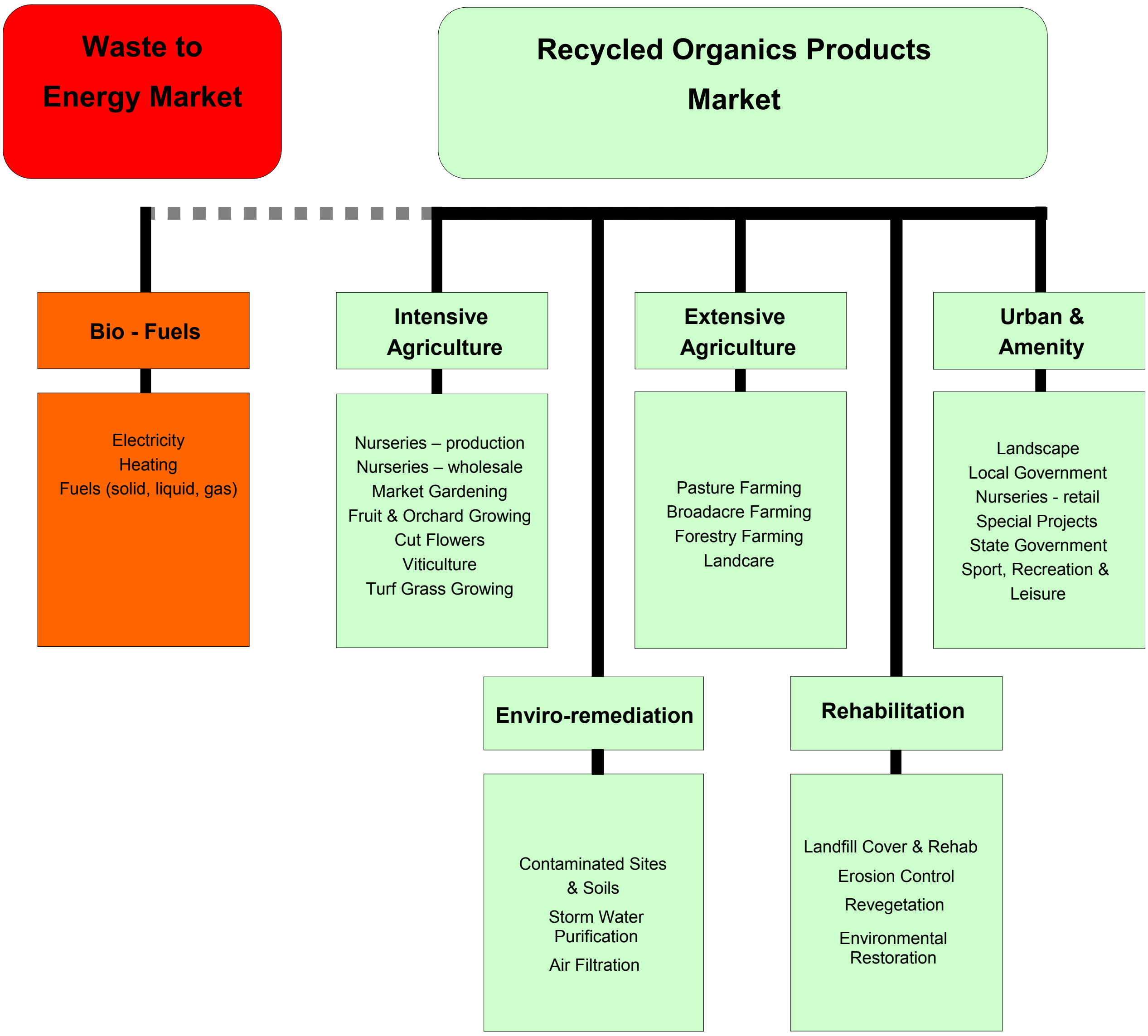
Markets for RO products have been identified and segmented, though many of the market segments can be considered as potential and/or emerging markets. The market structure developed for the recycled organics sector (Recycled Organics Unit, 2002) is presented in Figure 2.1.

The market structure for the recycled organics products shown in Figure 2.1 consists of five key markets, including: intensive agriculture, extensive agriculture, urban amenity, enviro-remediation and rehabilitation and the associated bio-fuels market (Recycled Organics Unit, 2002). These markets are further segmented into market segments. This report addresses only three segments in intensive agriculture market, namely

- viticulture,
- fruit and orchard production, and
- market gardening.

These three segments offer the largest documented demand potential in the intensive agriculture market for RO products (NSW Waste Boards, 1999).

Figure 2.1. Structure of the recycled organics products market – for existing and emerging products across the sector. (Source: Recycled Organics Unit, 2002).



2.2 The intensive agriculture market

Intensive agriculture is described as agricultural production in which large amounts of capital and labour are invested per hectare e.g. wholesale nurseries, cut flower growing, market gardens, fruit and orchard production, and viticulture. Intensive agriculture production can be undertaken either in open or under cover in growing structures such as glass houses, green houses and shade houses (NSW Waste Boards, 1999). Both situations use land and may potentially purchase RO products such as composts, garden soils and potting mixes (NSW Waste Boards, 1999).

Land area used for intensive agriculture is generally smaller than for extensive agriculture land uses such as broad acre farming and pastures. Intensive agriculture usually involves intensive cropping of the land that requires a greater amount of inputs per hectare in terms of fertilisers and other agricultural chemicals. Intensive agriculture also involves intensive working of land using practices such as ploughing, rotary hoeing, mounding, planting, fertilising and harvesting therefore the soil is more susceptible to on-site environmental impacts such as compaction, loss of soil organic matter and soil structure, wind and water erosion, salinity, soil borne diseases, and weed invasion and off-site environmental impacts including water pollution and loss of ecological integrity and biodiversity. Many of these symptoms reduce the productivity of the land and sometimes may require leaving the land fallow or adding organic materials such as green manure to increase soil productivity prior to further cropping. Recycled organics products are rich source of organic matter and their use in intensive agriculture can play an important role in rejuvenating the soil and assisting in the reduction of land degradation and to maintain ecological integrity and biodiversity.

The most recent market survey carried out by NSW Waste Boards (1999) identified the high potential of RO products in intensive agriculture market and its market segments for 1996 and 1998 (Figure 2.2). Figure 2.2 shows the turf, mushroom and cut flower market segments to be small, some of these are already using RO products. Given that these market segments display minor demand potential, this report focuses on viticulture, fruit and orchard production and market gardening segments, which offer significantly greater demand potential. Within the intensive agriculture sub-market, the viticulture segment has the highest reported additional demand potential for RO products followed by fruit and orchard production, nurseries and market gardening (Figure 2.2).

When comparing the potential of RO products in various market segments in 1998 compared to 1996, the data suggests there has been an increase in the potential RO products use in viticulture by 50,000 m^3, no change in fruit and orchard production and a slight reduction in market gardening (Figure 2.2). In NSW, the penetration of RO products into viticulture market segment is not significant, has reached about 25% in the market gardening segment, and has reached only 10% in fruit and orchard production segment suggesting a big potential of RO products use in these three market segments (Figure 2.2).

If government policy objectives are to be achieved in relation to the diversion and beneficial use of clean compostable materials from the solid waste stream, this identified market potential must be developed rapidly.

Figure 2.2. Existing and potential markets of recycled organics products in intensive agriculture market segments for 1996 and 1998 (Source: NSW Waste Boards, 1999).

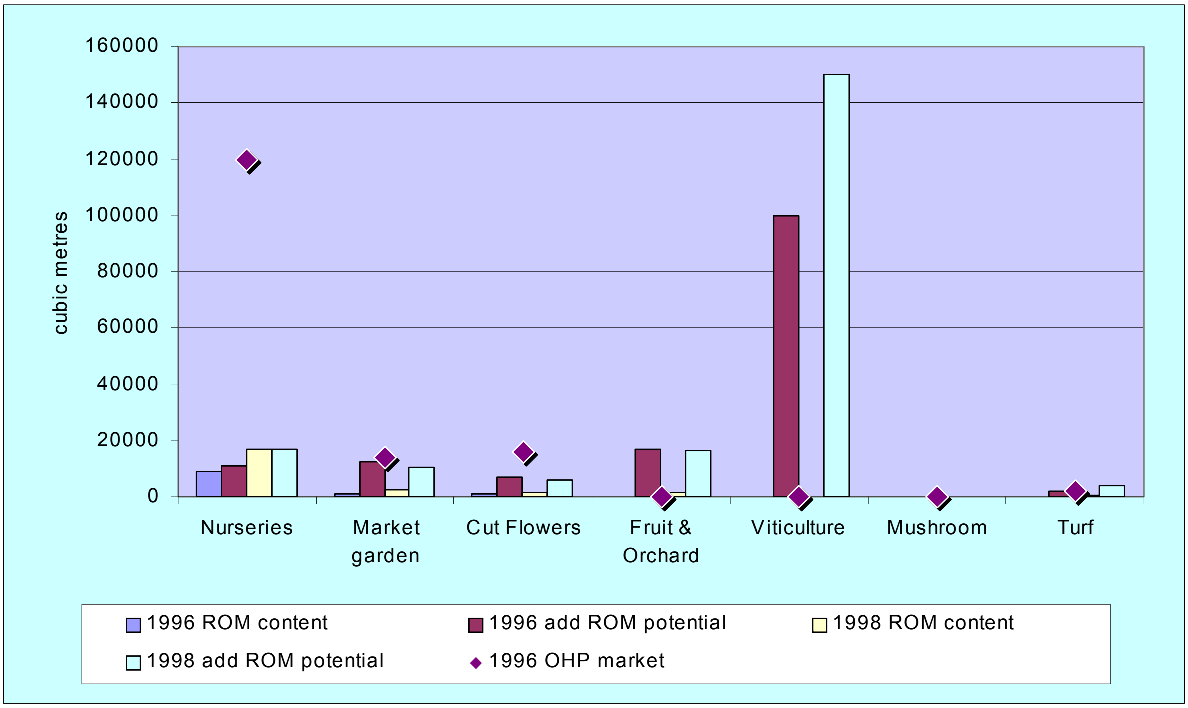


Table 2.1 Future demand trends of various recycled organics products in intensive agriculture market segments (Source: NSW Waste Boards, 1999).

Intensive Agriculture Market Segments	Mulches	Composts Conditioners	Garden Soils	Top Dressing	Potting Mix
Viticulture	High	High	Low	Nil	Nil
W/sale/Prod Nurseries	Low	Low	Low	Nil	High
Market Gardeners	Med.	High	Low	Nil	Low
Cut Flower Growers	High	High	Low	Nil	Med.
Fruit Growers & Orchards	High	High	Low	Nil	Low
Mushroom Growers	Nil	Low	Nil	Nil	Nil
Turf Grass	Nil	Low	Low	High	Nil

The NSW Waste Boards (1999) market study has reported the future demands of the intensive agriculture market segments by product category (Table 2.1). The Table 2.1 suggests that there is high potential demand for mulches and soil conditioners in viticulture, fruit and orchard production and market gardening.

Although market research information to date has identified the potential and future demand of RO products in intensive agriculture in New South Wales, the market specific needs, and the performance benefits for specific intensive agriculture applications have not yet been established (Recycled Organic Unit, 2002). Both market and technical research require to establish the performance requirements and specifications for products required by specific intensive agriculture market segments to support the penetration of RO products into these potential markets (Wilkinson, 2001; Recycled Organic Unit, 2002).

2.3 Previous research and development programs and their limitations

Over the last 10 years, various state departments, agencies and private enterprises across Australia have carried out R&D projects to characterise the performance of various RO products when applied to intensive agricultural crops. The findings of the research exist largely in the form of project reports and in most cases the results of this research have not been published, peer reviewed or made publicly available.

In Victoria, Institute of Horticulture Development has carried out field trials using composted mulches with a range of horticultural crops. In addition to this, some compost producers have also carried out demonstration trials to test and market their products for horticultural applications. The quality of findings from these trials varies.

NSW Agriculture has carried out several field research trials with biosolids and various composted products with variety of horticultural crops under various environmental conditions funded by Sydney Water, Waste Service of NSW and Australian Native Landscapes Pty Ltd. The results of these trials have shown a range of beneficial effects of composted products to horticultural crops, though short term cost effectiveness from composted products in agricultural production systems varied.

In South Australia, CSIRO Land and Water have tested composted mulches produced from garden organics on various horticultural crops and have shown significant increases in yields, improved soil moisture and weed suppression that have the potential to reduce production costs associated with the use of irrigation water and chemicals and show potential for revenues from higher yields.

Western Australia Agriculture has conducted a number of field trials with a range of composted products and horticultural crops on sandy soils, though savings in fertilisers, pesticide and irrigation costs varied across crops.

In 1999 coordinated field trials (New South Wales, Victoria, Queensland, South Australia and Western Australia) were organised in various regions covering these states across Australia to evaluate the benefits of using RO products in viticulture. These field trials demonstrated a range of potential benefits from the use of RO products but reliable cost/benefit data could not be obtained, except in South Australia, due to short term duration of these trials (Wilkinson, 2001).

The results of most studies have been based on one season monitoring and are not sufficient to reach conclusions for a management system which has long term effects such as RO product applications in agriculture. The tendency towards short term trials to assess the performance benefits and cost/benefits outcomes from RO product applications in intensive agriculture is a poor substitute for well designed and multi year (e.g. 3 to 6 years) scientific trials which are necessary to achieve these outcomes. This tendency for short term trials does not appear to result from the oversight of researchers, but rather from the limited, short term funding available to undertake such projects.

The economic analysis of the cost-benefits of using RO products in intensive agriculture carried out for some of these studies have measured direct economic benefits resulting from assumed yield increase and savings in reduced consumption of fertilizers, irrigation water, herbicides and pesticides. Multi year trials are essential for the quantification of economic cost/benefit, including the timelines and cost of repeat applications of RO products. It is necessary to off set the purchase costs and possibly for follow-up applications of RO products through recognition of the true dollor benefit arising from the application of these products to soils and intensive agricultural systems (Recycled Organics Unit, 2002). Recycled Organics Unit (2002) has reported that consideration of total benefits including economic, environmental and social benefits are needed for RO products to penetrate high volume markets outside urban metropolitan areas to sustainably divert compostable organic materials from metropolitan and regional landfills. Documenting total benefits on a triple bottom line basis will assist givernment to establish favourable policy and incentives for the application of RO products in agriculture.

2.4 Scientific and demonstration trials

Scientific trials are conducted to test the performance of particular treatments such as products and practices compared to existing or standard approaches, and to statistically demonstrate whether the treatment produced a significant effect or not. In other words scientific trials are designed to prove an effect.

Demonstration trials, traditionally are used when it has been already established, in scientifically trials, that a given product works. Therefore demonstration trials are designed to demonstrate a proven effect. They are not designed to prove an effect.

To achieve reliable outcomes from scientifc trials, an experimental design needs to be in place as well as a plan of management of trial outcomes, including sampling, chemical analyses, monitoring parameters and time and plan and method of statistical analysis. The experimental design should take into account the range of potential variables that can influence performance outcomes, to ensure that statistically valid data directly relevant to the relationship being studied is obtained. Selection of suitable parameters of analysis is essential (e.g crop yield and quality, soil quality improvements, disease suppression, weed suppression, soil moisture retention, palnt available water, etc.) to properly demonstrate the performance outcomes arising from the use of a RO products in an intensive agriculture system, and to identify why these outcomes have occurred. An experimental design for a scientific trial should be uniform, replicated, randomized and have a control for comparison. Importantly, the experimental design must be consistent with the objectives of the study, which requires clear objectives.

Uniformity of trial means growing a particular crop with uniform treatments in a field that has been equally divided into small units in which different treatments (e.g. different RO application rates) are randomly assigned. The crop is harvested and recorded from each separate unit. Variation in soil type and microclimate in the field should also be taken into consideration.

The repetition of the identical treatments under investigation is known as replication. The repetition of treatments allows averaging out the influence of experimentation (e.g. environmental differences) over different treatments. This is particularly important in order to statistically compare different treatments (e.g. whether RO product application at 10 t/ha resulted in improved water retention compared to the untreated control). Repetition also allows to identify individual treatments that fail to an unexpected phenomena, such failures would evidence dramatically different performance of other repetitions of the same treatment, motivating the researcher to look for an explanation for the variation.

Randomization or random allocation of the treatments to various plots allows objective comparison between treatments. Randomization ensures that various treatments by repetition will be subject to equal environmental effects and to ensure results are not biased by allocating certain treatments next to each other in a non-random manner.

The control is commonly, a treatment with no application of RO product, or a treatment with standard management practices. For example four composted soil conditioner treatments of 10, 20, 40 and 80 t/ha are compared with no compost treatment to evaluate effects in terms of soil moisture, plant available mositure and reduced irrigation requirement. No compost treatment is the control. The control allows the performance of products and costs/benefits to be compared with conventional practices.

In addition, scientific trials also include a pre-planning stage known as site and soil assessment. This is conducted to establish the suitability of the proposed trial site, including a soil assessment to evaluate the variability of the site and representativeness of the site of the agricultural region. In some cases, multi-site scientific trials may be performed to establish the performance outcomes and cost benefits across a region that may have highly variable soils and cropping conditions.

Demonstration trials are carried out mainly for promotional and market development purposes at much lower cost. Demonstration trials may lack experimental design and comprehenssive monitoring requirements, which is needed to confirm the performance of a RO product and to determine costs/benefits. For an example a demonstration trial studying benefits of RO products for grapevine may have only two not replicated treatments one with RO products, and another without RO products. The results of demonstration trials cannot be used to claim benefits in a quantitative sense as they lack experimental design, intensive monitoring and statistically valid results.

In the scientific trial, significantly greater pre-planning, pre-trial soil testing, monitoring and analysis is performed, with a corresponding higher cost. Ideally the scientific trial should span a number of years, in contrast the demonstration trial may span a single growing season and assists the transfer of scientific research into operational practice.

Advantages and disadvantages of scientific and demonstration trials are summarised in Table 2.2.

Table 2.2 Advantages and disadvantages of scientific and demonstration trials.

Type of trials	Advantages	Disadvantages
Scientific	• Site for trial should be chosen carefully to maintain uniformity of trial site. • Treatments are properly designed and replicated. • Treatments are randomised so that treatments are allocated to various plots by chance not by human choice. • Average production of treatments can be determined and compared with average production of the control. • Strict protocols are necessary to avoid biasing the results. • Background variability of the trial needs to be reported. • Trial results can be statistically analysed.	• Trials are expensive and time consuming. • Results of trials can be used to prove an effect of a treatment/product.
Demonstration	• Uniformity of trial site is not necessary. • It is not necessary to replicate and randomise the treatments • Strict protocols are not generally necessary.	• Trials are not expensive. • Reults of trials cannot be used to provide proof of a treatment/product effect.

Difference between scientific and demonstration trials has been illustrated in Figure 2.2. The varying treatments of composted mulches are replicated 4 times and allocated randomly in the field for a scientific trial (Figure 2.2a). Demonstration trial has two treatments mulched and unmulched without randomisation and may be replicated sometimes (Figure 2.2b).

Figure 2.2 Layout of treatments in field trials. (Treatments: A-control/no compost; B-composted mulch applied to 5 cm depth; C-composted mulch applied to 10 cm depth; D-composted mulch applied to 15 cm depth)

Figure 2.2a – Scientific trial

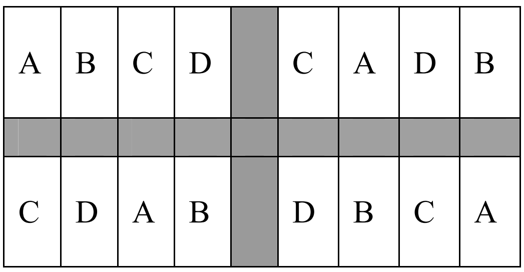
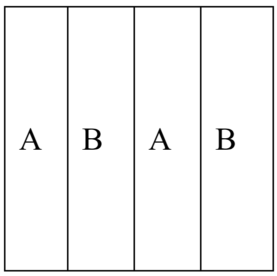


Figure 2.2b - Demonstration trial



To prove and quantify the benefits of recycled organics products for a range of applications, consolidated information on the performance benefits of RO products is needed for developing specific products that best meet the requirements of specific market applications that will help to access new markets. The consolidated information on the performance of RO products should be based on:

- Multi year R & D program (3 to 6 years),
- R & D program should be based on scientific trials,
- Scientific trials should be carried out across various (key growing) regions of NSW covering different soil types, climate, and farm management practices.

Wilkinson (2001) and Recycled Organics Unit (2002) have reported that both market and technical research are required to establish the product requirements and performance outcomes of products for specific intensive agriculture market segments. In addition to market and technical research, agricultural extension has also been identified for its potential role in assisting markets to successfully incorporate recycled organics products (where demonstrably benefical) into their agricultural production systems (Recycled Organics Unit, 2002).

2.5 Role of agricultural extension in accessing agricultural markets

There is no universal agreed definition of agricultural extension (Black, 2000). The Australasia Pacific Extension Network (1999) states that extension involves "the use of communication and adult education processes to help people and communities identify potential improvements to their practices, and then provides them with the skills and resources to effect these improvements". Marsh and Pannell (1998) define agricultural extension broadly to include: "…..public and private sector activities relating to technology transfer, education, attitude change, human resource development, and dissemination and collection of information".

One of the key elements of extension is that extension officers must have the confidence of the growers they work with. Extension officers commonly have relevant agricultural qualifications, and are commonly from a farming background, both of which give them credibility in the eyes of growers, and enable "empathetic communication" by the extension officer, which is one of the principles of adult education.

Over past 10 years the role of extension staff has been re-negotiated away from reactive, consulting kind of work (technology transfer) towards a more proactive, anticipatory problem solving approach due to increased questioning of public funding of extension services (Fell, 2000). This shift in government policy towards ensuring that services are provided rather than providing all the services, the resources (particularly the number of extension staff) are declining and aiming to do more with less (Fell, 2000). This approach probably reduces the amount of time spent in traditional approach of one-to-one assitance, and helps develop functioning networks that include farming families (and friends), extension personnel and technical specialists in an effective network of conversation (Fell, 2000).

The departments of agriculture in all states of Australia, except NSW, have either reduced the number of extension officers or closed extension services (Deuter, 2002; Murray, 2000). New South Wales being the fortunate state where agricultural extension services are still being maintained, albeit with the move from traditional one to one approach to group based training and education programs with an increased emphasis on competency based training. Considering the variety of perceptions and participatory approaches of growers, the role of agricultural extension officers can be successfully utilized in participation in scientific and demonstration trials, communicating proven benefits, and delivering educational and promotional materials that would increase the use of recycled organics products as a long term beneficial and cost effective component in the agricultural production systems.

2.6 Need for consolidated information on performance benefits of recycled organics products

Affordability, product quality and performance have been identified as key issues in the emerging markets for recycled organics products (NSW Waste Boards, 1999; Recycled Organics Unit, 2002).

Quantifying the performance of various RO products is one of the most significant barriers to the correct agricultural application of RO products. Performance varies across various regions and states due to varying product charateristics, climatic conditions, soil types, landforms, crops, varieties and management systems. Performance based products tailored match to the specific needs of intensive agriculture applications, with a minimum level of quality is one contributing strategy proposed to overcome barriers to the emerging intensive agriculture markets (Recycled Orgaics Unit, 2002). Product standards will provide assurance that the application specific RO products are produced to a consistent quality to meet the performance and value expectations of the user.

In order to develop markets in intensive agriculture for RO products, resources should be invested into specifying RO products that offer maximum cost/benefit advantage for particular applications, then demonstrating the performance and cost/benefits of these products to support market development. These market segments should strategically selected using criteria that target the maximum recovery of organic “waste” materials, financial viability and/or environmental benefits. Such criteria may include distance to market from metropolitan centres; value of market potential; market capacity to pay; and need for RO products in the intensive agriculture production system. In this context, previous studies have demonstrated that the viticulture, fruit and orchard production and market gardening market segments warrant initial exploration given their suitability and potential to benefit from the use of RO products (NSW Waste Boards, 1999). Before this can occur, however, gap analysis is required to indentify remaining gaps in information with regard to the performance of RO products in these market segments. Until this is performed, the application of resources to demonstrate the performance and cost/benefits of generic RO products in intensive agriculture applications is of very limited value to either government or the private sector.

High market potential for RO product categories such as mulches and soil conditioners has been identified in viticulture, fruit and orchard production and market gardening market segments. Large areas of these markets are available within 300-400 km radius of Sydney. The focus of this report will be to identify performance outcomes of RO applications and these product categories in these three market segments from the review of results of field trials carried out across Australia. This review will also identify the gaps and limitations in existing information for future investigations.

The research using RO products as surface mulches and soil conditioners in intensive agriculture internationally and nationally has shown a range of performance benefits such as the potential to increase soil moisture, suppress weeds, supply plant nutrients, reduce plant stress, maintain crop productivity and quality, improve soil health and prevent land degradation (NSW Agriculture, 2002). These performance benefits have the potential to reduce water use for irrigation, herbicides for weed suppression, fertilisers for plant nutrition resulting in the potential increase in farm revenue, reduced production costs, reduced risk of crop failure and increased farm capital value. Therefore this report will list the known performance outcomes arising as a result of application of RO products (as surface mulches and soil conditioners) in specific intensive agriculture applications, including viticulture, fruit and orchard production and market gardening. The performance benefits will be grouped under the following four categories: reduced risk of crop failure, increased revenue, reduced costs in farm management and increased farm capital value.

Section 3 Conclusions and recommendations

The majority of land degradation in Australia is related to low organic matter levels in soils, or can be amended by increasing organic matter levels in soil. An increase in organic matter can directly and indirectly correct land degradation problems such as sodicity, soil structure decline, and erosion. The application of the composted materials may be done directly on affected areas or in areas adjacent to affected areas. Restoration of these areas has multiple benefits both on and off site.

Where RO products are imported to increase organic matter, quantitative and qualitative benefits will be dependent upon the specific characteristics of the RO product used, the application rate, the method and timelines of application, environmental conditions, and post application management practices.

Generic results from generic product application will not provide consistent, reliable, nor optimum cost/benefit information, and are unlikely to overcome the documented affordability.

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Section 5 Glossary

All terms defined in this glossary are based upon definitions given in the Recycled Organics Industry Dictionary and Thesaurus, 2nd Edition (2002) unless otherwise noted.

Term	Definition
Agricultural organics	Any residual organic materials produced as by-products of agricultural and forestry operations, including: weeds (woody and non-woody); animals (processing residuals, stock mortalities, pests), and crop residuals (woody and non-woody), and manures.
Australian Standard	A Standard is a published document, which sets out specifications and procedures designed to ensure that a material, product, method or service is fit for its purpose and consistently performs the way it was intended to.
Biosolids	Organic solids or semi-solids produced by municipal sewage treatment processes. Solids become biosolids when they come out of an anaerobic digester or other treatment process and can be beneficially used. Until such solids are suitable for beneficial use they are defined as waste-water solids. The solids content in biosolids should be equal to or greater than 0.5% weight by volume (w/v). Biosolids are commonly co-composted with garden organics and/or residual wood and timber to produce a range of recycled organics products.
Carbon to nitrogen ratio (C:N ratio)	The ratio of the weight of organic carbon (C) to that of total nitrogen (N) in an organic material. Material with a large ratio (20:1) will break down slowly, while a small ratio (8:1) will quickly breakdown. Composted material with high C:N ratio when incorporated into the soil may cause a temporary nitrogen deficiency.
Compost	An organic product that has undergone controlled aerobic and thermophilic biological transformation to achieve pasteurisation and a specified level of maturity. Compost is suitable for the use as soil conditioner or mulch and can improve soil structure, water retention, aeration, erosion control, and other soil properties.
Compostable organics	Compostable organics is a generic term for all organic materials that are appropriate for collection and use as feedstocks for composting or in related biological treatment systems (e.g. anaerobic digestion). Compostable organics is defined by its material components: residual food organics; garden organics; wood and timber; biosolids, and agricultural organics.
Composted fine mulch	Any pasteurised product which has undergone composting for a period of not less than 6 weeks (excluding polymers which do not degrade such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Composted fine mulch has not more than 15% by mass of its particles with a maximum size above 15 mm.
Composted mulch	Any pasteurised product which has undergone composting for a period of not less than 6 weeks (excluding polymers which do not degrade such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Composted mulch has at least 70% by mass of its particles with a maximum size of greater than 15 mm.
Composted products	An organic product that has undergone controlled aerobic and thermophillic biological transfpormation to achieve pasteurization and a specified level of maturity.
Composted soil conditioners	Any composted product, including vermicast, manure and mushroom substrate, that is suitable for adding to soils. This term also includes 'soil amendment', 'soil additive', 'soil improver' and similar terms, but excludes polymers which do not biodegrade, such as plastics, rubber and coatings. Soil conditioner has not more than 20% by mass of particles with a maximum size above 16 mm.
Composting	The process whereby organic materials are pasteurised and microbially transformed under aerobic and thermophilic conditions for a period not less than 6 weeks. By definition, it is a process that must be carried out under controlled conditions yielding mature products that do not contain any weed seeds or pathogens.
Cultivation	Working the soil with implements in order to prepare it for sowing of crops.
Decomposition	The breakdown of organic waste materials by micro-organisms.
Demonstration trials	Demonstration trials are designed to demonstrate specific performance outcomes that have been proven by scientific trials.

Term	Definition
Dry matter	The portion of a substance that is not comprised of water. The dry matter content (%) is equal to 100% minus the moisture content (%).
Enterprise	The production of a particular commodity, for example oranges
Extensive agriculture	Refers to the market segment within the recycled organics sector, which incorporates: Pasture Farming, Broadacre Farming, and Forestry Farming.
Fallow	A farning practice in which land is left without a crop or weed growth for extended periods to accumulate soil moisture.
Feedstock	Organic materials used for composting or related biological treatment systems. Different feedstocks have different nutrient concentrations, moisture, structure and contamination levels (physical, chemical and biological).
Fertiliser	A substance that is added to the soil to supply essential nutrients for plant growth. Fertilisers may be natural or manufactured.
Fine mulch	Any composted and pasteurised organic product (excluding polymers which do not degrade such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Fine mulch has more than 20% but less than 70% by mass of its particles with a maximum size above 16 mm and complies with the appropriate criteria.
Food organics	The food organics material definition is defined by its component materials, which include: fruit & vegetable material; meat & poultry; fats & oils; seafood (including shellfish, excluding oyster shells); recalcitrants (large bones >15mm diameter, oyster shell, coconut shells); dairy (solid and liquid); bread, pastries & flours (including rice & corn flours); food soiled paper products (hand towels, butter wrap); biodegradables (cutlery, bags, polymers). Such materials may be derived from domestic or commercial and industrial sources. The definition does not include grease trap waste. Food organics is one of the primary components of the compostable organics stream.
Garden organics	The garden organics material definition is defined by its component materials including: Putrescible garden organics (grass clippings); non-woody garden organics; woody garden organics; trees and limbs; stumps and rootballs. Such materials may be derived from domestic, commercial and industrial and commercial and demolition sources. Garden organics is one of the primary components of the compostable organics stream.
Heavy metals	A group of metallic elements that include lead, cadmium, zinc, copper, mercury, and nickel. Can be found in considerable concentrations in sewage sludge and several other waste materials. High concentrations in the soil can lead to toxic effects in plants and animals ingesting the plants and soil particles.
Intensive agriculture	Refers to the market segment within the recycled organics sector which incorporates: Nurseries – production, Nurseries – wholesale, Fruit & Orchard Growing, Market Gardening, Mushroom Farming, Turf Grass Growing, and Viticulture.
Land application	The spraying or spreading of solid, semi-solid or liquid organic products onto the land surface, or their injection below the land surface.
Land degradation	The decline in land quality caused by improper use of the land.
Market penetration	Strategy for selling existing or conventional products into an existing or established market.
Market segmentation	The process of dividing markets into groups of consumers who are similar to each other, but different to the consumers in other groups.
Maturation	Final stage of composting where temperatures remain steady below 45ºC, and the compost becomes safe to use with plants due to the absence of toxins.
Maturity of compost	Is related to the level of composting feedstock material receives. A mature product is stable and does not cause toxicity to plants. See also Maturation and Stability.
Mineralisation	The breakdown of organic matter into its constituent inorganic components, carried out chiefly by decomposer microorganisms, and, for carbon, during respiration when carbon dioxide is returned to the environment.
Mulch	Any composted and pasteurised product (excluding polymers which do not degrade such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Mulch can be either composted mulches or pasteurised mulches. Mulch has at least 70% by mass of its particles with a maximum size of equal or greater than 16 mm.
Municipal solid waste	The solid component of the waste stream arising from all sources within a defined geographic area.
Organic matter	Chemical substances of animal or vegetable origin, consisting of hydrocarbons and their derivates.

Term	Definition
Pasteurisation	An organic product that has undergone controlled aerobic and thermophilic biological transformation to achieve pasteurisation, but is relatively immature and lacking in stability compared to compost.
Pasteurised fine mulch	Any pasteurised organic product (excluding polymers which do not degrade such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Pasteurised fine mulch has not more than 15% by mass of its particles with a maximum size above 15 mm.
Pasteurised mulch	Any pasteurised organic product (excluding polymers which do not degrade such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Mulch has at least 70% by mass of its particles with a maximum size of greater than 15 mm.
Pasteurised products	An organic product that has undergone pasteurisation (a process whereby organic materials are treated to significantly reduce the numbers of plant and animal pathogens and plant propagules) but is relatively immature and lacking stability.
Pasteurised soil conditioner	Any pasteurised organic material that is suitable for adding to soils. This term also includes ‘soil amendment’, ‘soil additive’, ‘soil improver’ and similar terms, but excludes polymers, which do not degrade such as plastics, rubber and coatings. Soil conditioner has not more than 15% by mass of particles with a maximum size above 15 mm.
Performance data	Quantification of performance benefits. For example quantifying mulching effcets on weed suppression.
Potting mix	A growing medium suitable for the establishment and development of a wide range of plants in containers.
Processing	Subjecting a substance to a physical, chemical or biological treatment or a combination of treatments. Composting, for example, is a form of processing.
Product development	Strategy for selling new or non-conventional products into an existing or established market.
Recycled Organics	The term Recycled Organics has been adopted by NSW Waste Boards and EcoRecycle Victoria as a generic term for a range of products manufactured from compostable organic materials (garden organics, food organics, residual wood and timber, biosolids and agricultural organics).
Recycled Organics Industry	A range of related business enterprises involved in the processing of compostable organics into a range of recycled organics products, and the development, assessment, marketing, promotion, distribution and application of those products.
Scientific trials	Scientific trials are conducted to test the performance of particular treatments such as products, latest technologies and practices over existing or standard approaches to statistically demonstrate whether the treatment produced a significant affect or not. An experimental design of a scientific trial should be uniform, replicated, randomized and have a control for comparison.
Screening	The process of passing compost through a screen or sieve to remove large organic or inorganic materials and improve the consistency and quality of the end-product.
Soil conditioners	Any composted or pasteurised organic product, including vermicast, manure and mushroom substrate that is suitable for adding to soils (excluding plymers which do not biodegrade, such as plastics, rubber and coatings. Soil conditioners any be either composted soil conditioners or pasteurised soil conditioners. Soil conditioners has not more than 20% by mass of particles with a maximum size above 16 mm and complies with appropriate criteria.
Soil degradation	Soil in which the structure has been damaged, compaction or erosion has occurred. It may also refer to soil acidity and salinity and the loss of nutrients from a soil.
Soil structure	The combination or arrangement of primary soil particles into secondary particles, unit, or peds. Compost helps bind primary soil particles to improve the structure of soil.
Stability of compost	The rate of change or decomposition of compost. Usually stability refers to the lack of change or resistance to change. A stable compost continues to decompose at a very slow rate and has a low oxygen demand. See also maturation.
Sustainability	In agriculture, sustainable practices are those, which are, and will continue to be, profitable for farmers, that will conserve soil, vegetation and water resources and protect the environment, and that will assure adequate and safe food supplies into the future.

Term	Definition
Toxicity	The potential or ability of a material to cause adverse affects in an organism.
Viticulture	Viticulture is the term used to describe grape growing for production of various products mainly for wine, dry grapes, fresh consumption (table fruits), juice for non-alcoholic consumption and concentrated juice.
Wood and timber	The material description, Wood and Timber is defined by its component materials, which include any contaminated or uncontaminated, treated or untreated, solid or composite wood material that include: off-cuts; crates; pallets and packaging; saw dust, and timber shavings. Such materials may be derived from domestic, agricultural, commercial and industrial, and construction and demolition sources. These materials may be contaminated with paint, laminate and fasteners. See treated timber. Wood and Timber is one of the primary components of the compostable organics stream.