Adelaide Mushrooms (Nominees) Pty Ltd
&
Australian Mushroom Growers Association

Spent Mushroom Compost for Viticulture

Field Evaluation & Market Development

January 2003
Contents

Summary & Recommendations 2
Background 4
Field Evaluation Methods 13
Field Evaluation Results 16

Attachments

Attachment 1: Brochure – Spent Mushroom Compost for Viticulture
Attachment 2: Brochure – South West Development Commission
Attachment 3: Trial Plan – Cabernet Sauvignon, Watervale, Clare Valley
Attachment 4: Trial Plan – Semillion, Watervale, Clare Valley
Attachment 5: Trial Plan – Shiraz, Watervale, Clare Valley
Attachment 6: Trial Plan – Meadows, Adelaide Hills
Attachment 7: Trial Plan – for testing spent mushroom compost
Field-trials have been established to determine the potential for the use of spent mushroom compost as a soil amendment for vineyards. Measures of yield, quality, growth, soil-structure, water-holding and earthworm activity have been undertaken to demonstrate the value of the spent mushroom compost as a surface-mulch and for soil incorporation prior to vineyard establishment.

**Field Evaluation** - Results from field evaluation of spent mushroom compost as a mulch and for soil incorporation, have identified benefits to soils and plants:

- Improved growth of newly planted vines with spent mushroom compost incorporated into the soil prior to planting.
- Increased yield with spent mushroom compost as a mulch under vines, indicating a potential to reduce irrigation while maintaining and managing yield and quality.
- Increased infiltration, moisture holding and biological activity in soil with spent mushroom compost as a mulch undervine.

**Features** - Spent mushroom compost has features which may make it more attractive for use as a soil amendment than other materials commonly used in commercial horticulture:

- The disciplined compost production methods required for mushroom-growing, ensure a consistent spent compost which should have predictable quality from season to season.
- Pasteurisation can provide assurance of freedom from pathogens and weed-propagules; horticultural producers are sensitive to the risks of pest and disease introduction.
- With a relatively low carbon to nitrogen ratio, the spent compost can be considered to have nutrient value, which may be desirable, particularly for soil incorporation.

**Use** – Field evaluation has assisted in identifying appropriate ways to use spent mushroom compost:

- Spent mushroom compost can be promoted for soil incorporation prior to vineyard establishment. Applications 50-75mm deep, 500mm wide along the vine rows, can be incorporated to 200-250mm in the soil.
- Spent mushroom compost can be promoted for surface application primarily as a soil conditioner, and also as a mulch. Depths up to 50mm will act as a mulch and add organic matter to soils. We advise against applications deeper than 50mm; the fine texture and relatively high nutrient content may encourage root growth within the mulch.
- There may be future opportunities to utilize other waste resources for blending and composting, but in the immediate term, we would encourage promotion of 100% spent mushroom compost, to assist in developing a recognised, identifiable, trusted product.
**Markets** – we consider that there is opportunity to move the entire production of spent mushroom compost into horticultural industries in proximity to Adelaide:

- In McLaren Vale alone, there are over 5,100ha of vineyards, and over 300 growers. 16,000m³ of spent mushroom compost would treat 190ha, or 3.7% of the plantings.
- At an average planting area of 17ha per grower, 12 of the 300+ growers treating their plantings would see demand outstrip current supply of spent mushroom compost. Efforts to promote spent mushroom compost could be efficiently contained within the region, with a relatively small uptake rate needed to see return on that effort.
- This large potential market exists within 20km of Adelaide Mushrooms; low freight costs, water-use restrictions, and a high level of awareness of the benefits of compost in this region make it an obvious target for marketing of spent mushroom compost.
- Orchards might be considered as a lower priority for marketing of spent mushroom compost; the larger areas of orchards within proximity to Adelaide are in higher rainfall areas with unrestricted water-use. Additional organic matter may be seen as unnecessary. But experiments with green-organics compost mulch have demonstrated benefits with cherry and pome (apples & pear) crops in the Adelaide Hills.
- Vegetable, berry and ornamental crops might also be seen as lower priority than vineyards for marketing spent mushroom compost; these markets don’t have the same capacity to absorb the material, and are more specific in their needs. But along with orchards, these markets can be passively developed, to diversify the horticultural industries involved, and help guard against down-turns in one industry.
- The spent mushroom compost should be registered with organic certification organisations (BFA and NASA) to allow promotion of the material to organic horticultural producers.
- The major barriers faced in the early development of markets for green-organics compost will pose less problems in marketing of spent mushroom compost; spreading machinery and contractors are now available, and the spent mushroom compost is free of the visual contamination which hindered acceptance of green-organics compost.
- An increasing trend in the wine industry to encourage growers to reduce or limit grape yields may pose a barrier to market development; additional organic matter and mulches may be seen by growers to work against reducing yields. Growers using spent mushroom compost as a mulch should be advised to monitor and adjust irrigation scheduling to take into account the additional moisture that will be stored in the soil.

**Promotion** – we consider that there is enough research data available to begin promotion of spent mushroom compost as a soil amendment for viticulture and horticulture:

- We have seen technical brochures successfully used to promote organic matter for horticulture in projects locally and interstate.
- We have attached four pages of text and figures which can be developed as a technical brochure for growers, outlining the benefits and use of spent mushroom compost.
- We expect to include results from field evaluation of spent mushroom compost in an article to be published in the Australian and New Zealand Grapegrower and Winemaker in July 2003.

We would be pleased to discuss the priorities of Adelaide Mushrooms and the Australian Mushroom Growers Association in determining the need for further field evaluation of spent mushroom compost.
BACKGROUND

In the past, satisfactory arrangements have been made for the ‘disposal’ of spent mushroom compost to potting and garden soil processors for inclusion in soil mixes. Adelaide Mushrooms generates over 16,000m³ of spent mushroom compost each year. With mushroom production set to rise from 40t/wk to 200t/wk, there is an immediate need to develop alternative markets within horticultural industries, for the additional 64,000m³ of spent mushroom compost that will be generated.

Marketing of organic amendments for landscaping and domestic horticulture is highly competitive, and penetrating these markets takes time and commitment. These markets may not realise the best returns for effort. Adelaide Mushrooms also has concerns that the compost quality is being compromised, with makers of soil blends mixing the materials with lower quality organic matter, but still labelling the material as “mushroom compost”.

Driven by the need to use water more efficiently, horticultural producers have shown increasing interest in using organic matter as a mulch (eg. straw, green-organics compost). With increasing amounts of spent mushroom compost becoming available, and demand from horticultural industries for effective and safe mulch materials, there is now opportunity for Australian mushroom growers to market this quality, consistent material directly to horticultural producers, retain control of the quality of the compost, and achieve economic returns from “waste” compost.

Field trials have been established in vineyards to evaluate the performance of spent mushroom compost and provide information on the benefits and use of the material. Through understanding the benefits of the spent mushroom compost, we can identify the most appropriate, immediate and substantial markets in horticultural industries.

Spent Mushroom Compost

Spent mushroom compost has features which make it potentially more attractive for use as a soil amendment, than many materials commonly used in commercial horticulture:

**Consistency** - the disciplined compost production methods required for mushroom-growing, ensure a consistent spent compost, which conforms to the Australian Standard for Composts, Soil Conditioners and Mulches (AS-4454 1999¹, DR-01337, 2001²). The spent mushroom compost should have a predictable quality from season to season, unlike common alternatives such as straw and green organics compost.

**Pasteurization** – the compost is pasteurised prior to mushroom-cropping, and is pasteurised again after cropping, to reduce the growth of “second-crop” mushrooms. These pasteurisations provide assurance of freedom from pathogens and weed-propagules, and will be attractive to horticultural producers, who are sensitive to the risk of pest and disease introduction.

---

¹ Australian Standards for Composts, Soil Conditioners and Mulches AS-4454, Standards Australia, 1999
**Nutrient value** – with a relatively low carbon to nitrogen ratio (C:N), the spent mushroom compost can be considered to have some nutrient value, which may be attractive to horticultural producers, particularly where the material will be incorporated in the soil. Analyses show that the spent mushroom compost has a C:N ratio of less than 15:1; as a comparison, green-organics compost mulches typically have a C:N of 25:1 or higher. This lower C:N ratio means spent mushroom compost is less likely to create “nitrogen drawdown”, where additional nitrogen required by decomposer organisms is taken from the soil and thus made unavailable for use by plants.

**Grade** - we expect there may be opportunities to promote the spent mushroom compost for use both as a mulch and for soil incorporation. The quality, consistency and nutrient content potentially makes the material ideal for soil incorporation. Where organic material is placed in close contact with the root system, the material must be “safe”, that is, free from plant pathogens and toxicities. As a mulch, the fine component will be readily incorporated in the soil while, the coarser fraction, which consists of undecomposed straw and peat moss aggregates, may provide residual surface protection.

In the longer-term, with operations relocating to a site more appropriate for large-scale composting, there may be opportunities to produce customised compost blends and to utilise other waste sources. However, in the immediate term, we would encourage promotion of 100% spent mushroom compost, to assist in developing a recognised, identifiable, trusted product.

**Field Evaluation**

Replicated, randomized field trials have been established in vineyards to determine the potential for the use of spent mushroom compost as a soil amendment for soil incorporation, and as a soil conditioner and mulch.

A trial has been established at Meadows in the Adelaide Hills with spent mushroom compost incorporated in the soil prior to planting of a new vineyard. This trial demonstrates the potential for spent mushroom compost to improve soil conditions for early vine growth. A commercially available green organics based compost (amended with rural wastes), has been tested alongside the spent mushroom compost, as an evaluation against the most likely local “proven” alternative.

Three trials have been established on a grape-growing property at Watervale in the Clare Valley. Spent mushroom compost has been spread undervine, and measures of vine growth, soil-properties, grape yield and juice quality have been undertaken to determine the value of the compost for improved vineyard management. The spent mushroom compost has been compared with straw, which is a readily available material often used for mulching by growers in the Clare Valley.
Benefits of Composts and Mulches

Although spent mushroom compost has not been tested in commercial vineyards, we can expect that it will have benefits; the material shares similar properties with green organics compost, which has been widely tested in commercial horticulture. We can expect that many of the principles applying to the use of green organics composts, will apply to spent mushroom compost.

Interest in the use of compost-mulches has increased over the past five years, with many growers considering these materials for improved irrigation management. Research has demonstrated the benefits of compost-mulch derived from green-organics, for water-saving, weed-control, soil structural improvement, increased soil biological activity, uniform establishment of young plants, and management of yield and quality.1,2,3,4,5,6

Field-trials with green-organics compost-mulches in vineyards and orchards have been in place for up to six years. Over forty sites are located across Australia, encompassing a range of climates and soils, and a range of crops including wine- and table-grapes, pomefruit, stone-fruit and citrus. Local factors are certainly important, but positive results in a range of conditions suggest there are some more basic principles at work. Protection of the soil surface with reduced fluctuations in soil moisture and temperature provides more favourable conditions for root-growth in the topsoil. We expect that these same principles will apply when spent mushroom compost is used as a mulch. Results from field-trials suggest that the compost grade (composition of particle sizes) and application rate are important in achieving good value from the mulch.

Green organics compost has also shown promise for soil incorporation, particularly prior to planting of new orchards and vineyards. But caution is needed where organic matter is incorporated around the rootzone. The material will be in direct contact with the all of the root system of the developing young plants, making any toxicities more likely to cause detriment. The compost must be of good quality, and well processed to minimise the potential for any toxic effects on new plants. Spent mushroom compost has a consistent and predictable quality, which may make it ideal for soil incorporation, and could be favoured over alternative composts.

1 Buckerfield, JC and Webster, KA, Compost as mulch for managing young vines, The Australian Grapegrower and Windemaker, No. 418, pp. 75-78, 1998.
6 Buckerfield, JC and Webster KA, Composted green-organics for use in horticulture – reporting recent studies with orchards, vineyards and vegetables, South West Development Commission publication, PO Box 2000 Bunbury WA 6231, 2001.
**Soil Moisture** - Results have demonstrated the potential to reduce reliance on irrigation. A surface covering of compost mulch reduces loss of moisture from the soil by evaporation, and reduces fluctuations in soil moisture and temperature. With a compost mulch under vines, we calculated that water-use could be reduced by a third; with the biggest inputs of salt originating in irrigation water, mulch can have a significant impact in reducing soil salinity.

**Plant Growth & Yield** - Trunk diameter is a useful measure of plant-growth, often correlating with yields. With sufficient measurements, differences related to compost-mulch may be obvious within months (Fig. 1). The increased trunk-diameter indicates a more rapid development of young plants and improved performance of established trees and vines. We have recorded increased yield in response to compost-mulch on a range of crops including wine- and table-grapes. Benefit-cost analysis of trials in vineyards has demonstrated returns of around $2.60 for every $1.00 invested in the mulch, for an application 50mm deep.

**Soil Properties** - Changes in infiltration rate are consistently seen, and rates are often increased two to five times with compost-mulch. Similar increases have now been demonstrated on a variety of soils, including coarse sands (Fig. 2) and heavy clays (Fig. 3). Changes in soil-strength have been seen within twelve months of establishing trials (Fig. 4). Reduced soil-strength enables plant roots to explore, and make more efficient use of the soil. With the additional carbon food source, compost-mulch can increase earthworm abundance and activity in the soil (Fig. 5). We expect that the beneficial changes in soil structure are often associated with increased earthworm activity, with burrowing and mixing of the soil assisting movement of water and nutrients into the rootzone.

Earthworms live in close contact with the soil, and have long been considered an indicator of “soil-health”. Our results have demonstrated that they respond rapidly to changes in soil conditions, and they may be an accurate indicator of the effect of the applied organic matter on soil biological activity.

The effects of compost-mulch on plants and soils have been largely positive. We conducted measures of soil-strength, soil-moisture, infiltration-rate, earthworm activity and trunk-diameter on over thirty sites in 2001. Each of these sites showed a positive response in at least one of the measures.

**Negative effects of compost mulches** – our results show that less favourable effects on plant growth and yield have been related to the grade of the organic matter, and the depth of application. Problems with lower soil moisture, reduced biological activity, increased soil-strength, root growth above the soil surface, and effects on plant growth and yield show that application rate and grade are critical determinants of mulch performance.

---


In a table-grape vineyard measured during winter, soil moisture was reduced with increasing rate of compost mulch (Fig 6). Under mandarins, earthworm abundance was dramatically increased with compost-mulch, but higher rates were less effective (Fig 7). In a vineyard, earthworm activity was reduced by compost-mulch application, where a cereal-pellet mulch was more effective (Fig 8).

A deep layer of fine organic material is likely to be highly absorbent, and can reduce movement of water into the soil below. Fine materials also provide an alternative soil layer, and roots may establish above the soil surface, where the compost will no longer be acting as a mulch. A fine, deep layer of compost may also affect the burrowing activity of some earthworm species.

**Get the grade right, get the rate right** – results suggest that a mix of fine and coarse compost is most appropriate for surface application. The finer fraction is readily incorporated into the soil by earthworms, while the coarser materials will remain, and provide surface protection.

Results have demonstrated that finer materials perform well at lower rates, but the effects are reduced at higher rates (Figs. 6 & 7). Optimal application rates for finer materials will depend on particle size, water-holding and nutrient content. Rates between 25mm and 50mm may be more appropriate for finer materials, including spent mushroom compost.

Although there has been limited field experimentation with organic matter for soil incorporation, many growers have identified the potential benefits of this practice and successfully used organic amendments in the soil prior to vineyard establishment. Depths of 50-75mm have been spread 500mm wide on the soil surface along the vine rows prior to ripping and cultivation. The material can be rotivated into the soil to a depth of 200-250mm, which gives a concentration in the soil of around 20-25%.

We strongly advocate leaving areas within new orchard and vineyard applications untreated. Three groups of ten vines or trees, in six rows alternating with treated trees and vines, will provide the minimum number required to undertake simple monitoring. Basic measures such as trunk diameter can assist a grower in confirming the benefits of spent mushroom compost. We have supplied a simple trial plan (Attachment 7), which can be given to growers who purchase spent mushroom compost, to enable assessment of the benefits of the material.
Figure 1 – Trunk diameter (mm) of vines

Figure 2 – Infiltration in coarse sand under vines

Figure 3 – Infiltration in clay soil under vines

Figure 4 – Soil strength under vines

Figure 5 – Earthworm density under vines

Figure 6 – Soil moisture under vines

Figure 7 – Earthworm density in mandarins

Figure 8 – Earthworm density under vines
Markets & Barriers

**Wine-grapes** – There are over 12,000ha of bearing and over 1600ha of new plantings (non-bearing) grapevines in the South Australian Central District¹. This district covers metropolitan Adelaide (including the northern Adelaide Plains) the Adelaide Hills, Alexandrina, and Fleurieu (including McLaren Vale) regions.

At an application rate of 500mm wide and 50mm deep, 16,000m³ of spent mushroom compost would treat around 190ha as a mulch (or incorporated into the soil in new vineyards). That is, around 1.5% of all plantings in the South Australian Central District could be treated each year. 80,000m³ would treat around 970ha, or 7% of all plantings in the Central District.

In McLaren Vale alone, there are over 5,100ha of vineyards, and over 300 growers³. 190ha would be 3.7% of the plantings, and 970ha would be 19%. At an average planting area of 17ha per grower, 12 of the 300+ growers treating their entire plantings would lead to demand outstripping the current supply of spent mushroom compost. A very large potential market exists within 20km of Adelaide Mushrooms.

Viticulturists consider that Environmental Management Systems will be commonplace in vineyards within the next five years⁵,⁷. Requirements for "environmental" management of vineyards may see an increasing demand for the use of recycled organic (compost) materials in viticulture.

**Orchards** – the orchards of the Adelaide and Outer Adelaide statistical regions are dominated by pome fruit (apples, pears, nashi) and cherries⁹. There are over 830,000 pome and cherry trees in production in these regions. At an application rate of 50mm deep, in a 1x1m square around each tree, 16,000m³ of spent mushroom compost would treat 320,000 trees, or around 40% of the orchard trees around Adelaide each year. 80,000m³ would treat 1,600,000 trees, or almost twice the orchard area around Adelaide.

Pome and cherry crops are grown in higher rainfall areas, with unrestricted access to high quality irrigation water. Growers have minimal incentive to save water, so mulches and soil conditioners may be seen as unnecessary. But trials in cherries and pears with compost mulches have demonstrated benefits to yield, quality and soil properties.

Other orchard crops, such as stone fruit, olives, nut crops and citrus, are grown in the regions around Adelaide; areas of these crops are small. These crops are now mainly grown in the Riverland and South East⁷.

---

**Other** – Adelaide Mushrooms has already investigated other markets, including strawberries and ornamental horticulture. There are around 53ha\(^7\) of strawberries grown in the Adelaide and Outer Adelaide regions. At 30m\(^3\)/ha, 16,000m\(^3\) would treat around 530ha.

Production of vegetable, flower and ornamental crops, in field and glasshouses is centred largely in the Northern Adelaide Plains. Initially, compost producers found this region difficult to penetrate, due to a diversity of production methods, and quality assurance requirements. After five years of promotion, compost producers are now penetrating this market, with the compost promoted as an alternative to manures.

Spent mushroom compost may have an advantage over other composts; many vegetable growers must supply quality assured produce, which requires the use of quality assured inputs. Mushroom compost may be easier to quality assure than other compost alternatives.

**Barriers** - The two major barriers to marketing of recycled organic materials in commercial horticulture have been lack of spreading machinery, and presence of visual contamination\(^1\). In the five years since development of markets for green-organics compost began, problems with spreading have been largely solved. Effective machinery is now available with experienced spreading contractors to operate it. Spreading should not pose a barrier to development of markets for spent mushroom compost. Being free from visual contamination, the material should have an advantage over composted green organics, and can be promoted as “clean” organic matter.

In wine grape production, a new barrier to market development for organic amendments has emerged; winemakers are encouraging production of lower yields, or, demanding that growers keep yield below certain thresholds. Application of organic matter to vineyards may be seen to work against lower yields. However the increased yields seen in trial results may be an indication of the potential to reduce irrigation, without need to increase yield.

**Market summary** - we consider that there is opportunity to shift the entire production of spent mushroom compost into vineyards close to Adelaide. The current production of 16,000m\(^3\) of spent mushroom compost would treat around 1.5% of all vineyard area in the South Australian Central District (within 100km of Adelaide), or 3.7% of vineyard area in McLaren Vale alone (within 20km of Woodcroft). The proximity of these markets will limit freight expenses, and make prices of spent mushroom compost most competitive.

Water restrictions and increasing expectations for “environmental viticulture” mean that many growers have already considered additional organic matter for soil and irrigation management. In the McLaren Vale region, growers have been exposed to education on compost mulches for improved irrigation management for almost seven years, and levels of awareness of the benefits of compost are already high. Spent mushroom compost has an advantage over green-organics compost, in being “clean” (free from visual contaminants) and “safe” (pasteurised).

While vineyards would seem to provide an ideal outlet for spent mushroom compost, the other smaller markets will be important supplementary outlets for spent mushroom compost. Diversity in the horticultural industries involved will help protect against downturns in one market.

---

Communication and Promotion

We have seen technical brochures used successfully in other projects to promote the benefits of recycled organic materials to horticultural producers. A discussion of benefits, potential problems, application rates, and a selection of experimental results can be presented in a “handout” format.

We have supplied four pages of text and figures (see Attachment 1), which can be used to develop a technical brochure for growers. Additional information might include a “typical analysis” of the material, and specific contact details for sales enquiries at Adelaide Mushrooms. We have attached an example of how similar information has been used to develop a technical brochure\(^1\) for a green organics compost project in Western Australia (Attachment 2). We will be pleased to assist further in developing the brochure.

Excerpts from the brochure can be used for Australian Mushroom Growers Association newsletters and publications\(^2\). We expect to use results from the project in an article on organic matter management in vineyards for the Australian and New Zealand Grapegrower and Winemaker Annual Technical Issue, due out in July 2003.

---


\(^2\) EcoResearch retains copyright of the brochure text and figures, but we encourage wide use of the information – please seek confirmation from the authors before using the information in publications and promotional materials.
FIELD EVALUATION METHODS

Trials have been established in vineyards at Watervale (Clare Valley) and Meadows (Adelaide Hills), to look at the performance of spent-mushroom compost as a mulch and soil-amendment, in comparison with the local alternatives.

The trials at Watervale have been installed in mature semillion and cabernet sauvignon vines, and in young Shiraz vines. The performance of the spent mushroom compost has been compared with straw mulch, which is a readily available and commonly used mulching material in the Clare Valley.

At Meadows, spent mushroom compost has been incorporated into the soil prior to vineyard establishment, with the grower seeking improved soil conditions for the growth of new vines. The compost has been compared with a green-organics based compost (amended with rural wastes).

Schedule of field evaluation

Trials were initiated over two years ago, and we have up to two years of yield, quality, plant growth and soil property data, to demonstrate the benefits of spent mushroom compost in vineyards.

<table>
<thead>
<tr>
<th>Site</th>
<th>Trial Installation</th>
<th>Yield &amp; Quality</th>
<th>Plant Growth</th>
<th>Soil Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Shiraz</td>
<td></td>
<td>9th April 2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watervale</td>
<td>Sept. 2000</td>
<td>5th May 2001</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(b) Cabernet Sauvignon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watervale</td>
<td>Sept. 2000</td>
<td>5th May 2001</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(c) Semillion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meadows</td>
<td>29th June 2001</td>
<td>-</td>
<td>14th May 2002</td>
<td>-</td>
</tr>
</tbody>
</table>

Trial Design & Establishment

Trials have been designed to take into account site features such as slope, drainage and soil type. Randomization and replication have enabled us to check that results obtained are meaningful and can be confidently interpreted.

Trial designs for the three sites at Clare, and the trial at Meadows, are presented in Attachments 3-6.
Yield & Quality

In the viticulture industry, yield is not a clear-cut issue; more may not be better, and winemakers may now favour grapes from “low-yielding” vines, or demand that growers keep yield below certain thresholds. However in these trials, increased yield may be an indication of the potential to reduce irrigation. Mulched vines may be receiving irrigation in excess of requirements. With reduced irrigation, it may be possible for growers to use mulches without increasing yield. And with moderation of soil temperature and moisture fluctuations, growers may have more scope to fine-tune irrigation for optimum quality.

Determination of bunch number and berry weight enables us to calculate bunch weight, and berry number per bunch. With this, we can determine whether increased yield has been a result of more bunches, bigger berries, or more berries per bunch. The way the yield has increased may be important for quality. For instance, winemakers may consider that bigger berries are undesirable.

Simple quality parameters have been measured. Juice °Brix provides a measure of the sugar content of the juice, and is a factor often used by winemakers to schedule harvest. pH is a measure of juice acidity, and together with titratable acicity, indicates potential for quality and keeping of the wine.

**Yield** – grapes harvested from replicate sections of vine-row were weighed, for determination of yield per vine.

**Bunch Number & Bunch Weight** – the number of bunches from each replicate section of vine-row were counted, and bunches per vine determined. Bunch weight was calculated for each section of vine row, by dividing yield by bunch number.

**Berry Weight & Berry Number** – ten randomly selected bunches were subsampled during bunch-counting, and five berries randomly taken from each bunch. The fifty-berry sample was weighed. Berry number per bunch was determined by dividing bunch weight by berry weight.

**Brix, pH & titratable acicity** – 50 berry samples were sent to the Analytical Service at the Australian Wine Research Institute, for determination of basic quality parameters (Brix, pH & TA) on the free-run juice.

Plant Growth

Trunk diameter is a useful measure of plant-growth, often correlating with yields. Increased trunk-diameter indicates a more rapid development of young plants and improved performance of established trees and vines.

With new vines, many growers encourage strong early growth and trunk development to enable training of the vines on the cordon wire. Where growers are aiming to get the vines to the wire, vine height is a useful measure of growth and response to treatments.

**Trunk diameter** – vernier calipers were used to provide replicate measures of trunk-diameter on each vine recorded at the height of the wire supporting the dripper-line.

**Vine height** – the height of each vine from the ground to the growing tip was measured with a tape measure.
Soil Properties

We have developed a set of measures which reflect how efficiently soil and water are being utilized. The measures are conducted during the winter months, when earthworms are active in the soil. Earthworms have been linked to agricultural sustainability\textsuperscript{1,2,3} and their populations can indicate soil carbon levels and soil conditions that encourage biological activity, root growth and nutrient cycling. Their activity in the soil creates burrows, and channels for movement of water and air.

Soil strength is a measure of the pressure that must be applied to push a rod into the soil, and might be equated to the difficulty that a plant root experiences in pushing through the soil as it grows. Levels above 2MPa are considered to inhibit vine root growth.

Infiltration is a measure of the rate at which water can penetrate the soil surface. Low infiltration rate can lead to pooling of water on the soil surface, where it is more susceptible to evaporation. On slopes, this water may move across the soil surface, carrying soil and nutrients and potentially causing erosion.

Soil strength and infiltration are affected by soil moisture. We measure soil moisture to check that levels in each treatment are similar, and that the results are comparable.

An appropriate sampling-plan was determined, taking into account the trial-layout and site features, such as slope, drainage, aspect and soil-type.

**Soil-strength** - A 12mm penetrometer was pushed into the soil under the vine-row as far as physically possible (up to 60cm); soil-strength was recorded at 2cm intervals.

**Soil-moisture** – A portable reflectometer (TDR) probe was pushed vertically into the soil to a depth of 30cm; soil-moisture (%) was integrated over this depth.

**Infiltration Rate** – Infiltration rings (200mm diameter) were driven 5cm into the surface soil. With the soil pre-wetted, the time for infiltration of three consecutive litres of water was recorded.

**Earthworm activity** – Blocks of soil 0.1m\textsuperscript{2}, to 10cm deep, were taken midway between vines, under the vine row, and handsorted for earthworms. Earthworm numbers, species and weights were recorded for each sample.

Statistical Analyses

**Means and standard errors** - statistically significant differences between treatments (P<0.05) were determined with analysis of variance and least significant differences on the replicate samples for each treatment.


FIELD EVALUATION RESULTS

Yield & Quality 2001

Yield parameters (yield, bunch number, bunch weight, berry number) and quality (berry weight) were assessed on the selected Cabernet Sauvignon trial on the 5th of May 2001. On the same date, we were able to assess bunch numbers in the earlier harvested Semillion and Shiraz trials, by picking and counting the bunch stalks left behind after mechanical harvest.

**Shiraz** – Bunch numbers for both the spent mushroom compost and straw treatments were higher than the control. For vines with spent mushroom compost, bunch number was significantly higher, with over 20% more bunches than the control (Fig. 1).

![Figure 1](image1.png)

**Semillion** - differences in bunch number in the mature semillion vines were not significant. Both the mushroom-compost and straw treatment had fewer bunches than the control (Fig. 2).

![Figure 2](image2.png)
**Cabernet Sauvignon** – spent mushroom compost did not affect yield; increases in yield were related to straw mulch (Fig. 3). This response was associated with significantly higher bunch number in the straw treatments (Fig. 4). Bunch weight was not significantly affected by treatment (Fig. 5). Berry weight was significantly higher with straw alone (Fig. 6). Berry number was significantly reduced with the straw treatments (Fig. 7).

Overall, mushroom compost did not significantly affect yield parameters, but straw mulch treatments had higher yield, with more bunches, containing fewer, but larger berries.
Figure 5
Bunch Weight (g)
Cabernet Sauvignon
Watervale 05/05/01

Figure 6
Berry Weight (g)
Cabernet Sauvignon
Watervale 05/05/01

Figure 7
Berry number (per bunch)
Cabernet Sauvignon,
Watervale 05/05/01
**Yield & Quality 2002**

Based on results from the 2001 harvest, the Shiraz trial was selected for detailed harvest analysis for the 2002 vintage. The trial had been established in a vineyard with uniform growth, and the treatments had been uniformly applied. This trial had a higher degree of replication, and the data on bunch counts from the previous harvest had low standard error, and a low probability that results were due to chance alone.

Yield was significantly higher with spent mushroom compost, and was increased by 30%. Straw mulch did not increase yield (Fig. 8). The increase in yield was due to a significant increase in bunch number, with 25% more bunches on vines treated with spent mushroom compost. With straw mulch, bunch number was increased 15% (Fig. 9). Bunch weight, berry weight and berry number per bunch were not significantly changed with spent mushroom compost (Figs. 10-12). With straw mulch, bunch weight was significantly reduced by 10%, associated with a significant reduction, by 10%, in the number of berries per bunch (Figs. 10 & 12). Berry weight was not affected by straw mulch (Fig. 11).

Juice pH and titratable acidity were not affected by treatment, but juice brix was significantly reduced with spent mushroom compost, and was over 5% lower than the control (Figs. 13-15).
Figure 10
Bunch Weight (g)
Shiraz
Watervale, 09/04/02

Figure 11
Berry Weight (g)
Shiraz
Watervale, 09/04/02

Figure 12
Berry number (per bunch)
Shiraz
Watervale, 09/04/02
**Figure 13**

Juice Sugar (°Brix)
Shiraz
Watervale, 09/04/02

**Figure 14**

Juice pH
Shiraz
Watervale, 09/04/02

**Figure 15**

Juice Titratable Acidity (g/L)
Shiraz
Watervale, 09/04/02
Plant Growth

**Watervale** – no change in trunk diameter was recorded where spent mushroom compost and straw were applied as mulches undervine (Fig. 16).

![Figure 16](image1)

**Meadows** – where spent mushroom compost was incorporated in the soil, young vines were 20% taller, ten months after planting, than control vines (Fig. 17). The taller vines had almost twice as much shoot growth above the height of the cordon wire (Fig. 18).

![Figure 17](image2)
Soil Properties

*Infiltration* – where spent mushroom compost was applied as a mulch, infiltration rate was increased by over 40%, though this increase was not statistically significant. Under straw-mulch, infiltration was increased by 20% (Fig. 19).

*Soil strength* – soil strength was not significantly affected by mulch treatment and there was no significant trend down the soil profile, related to treatment (Fig. 20). At 0-40cm in the soil, soil strength was at levels that would not be considered inhibitory to vine root growth.
**Earthworm activity** – with spent mushroom compost undervine, earthworm density was increased by over 40%, and biomass was increased over 60% (Figs. 21 & 22), although these increases were not statistically significant. Earthworms were active above the soil, working in the spent mushroom compost. Earthworm density and biomass were unchanged by straw mulch (Figs. 21 & 22). We expect straw mulch to take eighteen months to become fully effective.

The mean weight of individual earthworms was not significantly reduced by the mulch treatments (Fig. 23). The species recorded at this site were *Aporrectodea trapezoides*, *Aporrectodea rosea*, and *Microscolex dubius*.

The additional earthworm activity may have assisted in creating better conditions for water movement into the soil; increases in earthworm activity correlated closely with increased water infiltration for both treatments.
Spent Mushroom Compost for Viticulture
EcoResearch
Field Evaluation & Market Development

Soil Moisture – soil moisture was significantly increased with the mulch treatments (P<0.05). Under mushroom compost, moisture increased from 29% to 35% (Fig. 24). This increase will have minimal influence on measures of soil strength and infiltration, which are affected by soil moisture levels.
Summary of results

**Yield and Quality** – results from the Shiraz trial have shown that there were 20% more bunches at harvest in 2001, and a 30% increase in yield in 2002, due largely to a 25% increase in bunch number. We consider these results to be reliable, with statistical analyses showing low variability in the data. This trial was in a uniformly established young vineyard, on a level site, with twice the replication.

The increased yield was without significant change in berry size, which in red grapes, may be important to the winemaker. Smaller berries have a higher ratio of grape skin to grape juice; the grape skin gives the uncoloured grape juice its red colour. There was no significant change in pH or TA, although TA appeared to be around 5% higher with spent mushroom compost. The reduced juice sugar (brix) may be of concern, but may indicate the opportunity either to reduce irrigation, or to harvest earlier or later. With the whole vineyard treated, ripening could be managed optimally. In this trial, irrigation and harvest could not be optimised for each treatment.

Overall, results for yield and quality have been positive. Increased yield has been a result of increased bunch number, or, increased capacity of the vine, rather than a result of “pumped up” berries. Juice pH has been unchanged, and the balance of reduced juice sugar and increased acids suggests that vines with spent mushroom compost may have benefited from later harvest. We expect that the ripening and vine “balance”, or capacity, could have been managed with irrigation optimised for this treatment.

Harvest data from the Cabernet Sauvignon and Semillion trials in 2001 were less encouraging, and showed that spent mushroom compost had no significant effect on grape yield. There is a higher degree of variability within these vineyards, with less uniform growth of the mature vines on sloping sites. Shoots which were touching the ground had “swept” the compost and straw away from the undervine, leaving the ground bare in areas. So while we don’t discount these results, we note that there is a higher degree of variability in the data, and limit our interpretation of the results. These trials remain in place and there will be opportunity to revisit them at a future time.

**Plant growth** – Results have demonstrated benefits in the establishment of newly planted vineyards, where spent mushroom compost has been incorporated in the soil prior to planting. The extra shoot growth above the cordon wire will enable the grower to wrap more cane along the cordon wire, to get the structure of the vine established. The increased growth is likely to reduce training costs; fewer passes over the vineyard will be needed to prune and wrap-down the canes.

Many growers have already identified the benefits of incorporating organic matter in the soil prior to planting, and have used green organics compost. The results seen with spent mushroom compost are similar to those seen with green organics compost. But we would consider that spent mushroom compost has an advantage; it’s consistency and pasteurisation make it “safe” to place in close contact with young plant roots.
Soil properties – infiltration rate was increased by over 40% with spent mushroom compost. This increased infiltration will assist in reducing the pooling of irrigation water under drippers, and reduce evaporation from the soil surface. In winter, the increased infiltration will allow storage of more rainfall in the soil and reduce movement of water across the surface, carrying soil and nutrients and potentially causing erosion. Already we have seen improved storage of winter rainfall, with higher soil moisture under the spent mushroom compost, ready for use by the vine during spring.

The increased infiltration is linked with increased earthworm activity; earthworm density was increased by 40% with spent mushroom compost. The additional burrowing activity has created channels for movement of water into the soil surface. Over time, we can expect the increased burrowing activity will also “soften” the soil, reducing soil strength. This effect had not yet been seen; one year after application of spent mushroom compost, no significant changes in soil strength were recorded.

Earthworms were active above, the soil, working in the spent mushroom compost. The soil working species are associated with conditions suitable for root growth. Earthworm activity within the mulch, above the soil surface, may be an indication of the potential for vine roots to grow within the mulch, above the soil surface. We view root growth in mulches as a possible negative. With the roots above the soil surface, the mulching effect is lost, and the vines have access to a source of nutrients that the grower can not manage or control.

We see the activity of earthworms in the spent mushroom compost as an indication that for use as a mulch, application recommendations should advise against depths greater than 50mm. As a mulch, rates from 25-50mm may be most appropriate. We would suggest that longevity is not promoted as a characteristic of spent mushroom compost; with the low carbon:nitrogen ratio, we can expect to see rapid breakdown of the material. Incorporation of the mulch into the soil will be further hastened by the activity of earthworms, particularly as this appears to be a food source favoured by earthworms. Spent mushroom compost should be promoted primarily as a soil conditioner, to restore organic matter and biological activity, and improve soil structure.

Summary - Overall, we have positive results for yield and quality, demonstrating opportunity to increase the capacity of vines, or reduce irrigation while maintaining yields. In this case, the increased yield in the second year would have resulted in an extra $4,200/ha in crop value. The grower could afford to pay up to around $50/m3 for the spent mushroom compost, freight and spreading, and still break even with the increased crop value in the second year alone.

In addition, the results show the opportunity to improve the establishment of young vines, with potential to reducing training costs and time. Improvements in soil properties, with increased infiltration, moisture and earthworm activity can be expected to persist for some years, and we can also expect to see reduced soil strength over time. These results can provide the basis for promotion of the benefits of spent mushroom compost, and assist in market development.

SPENT MUSHROOM COMPOST FOR VITICULTURE

Field-trials have demonstrated the benefits of spent mushroom compost as a soil amendment for vineyards.

Incorporated in the soil prior to vineyard establishment, the spent mushroom compost can improve early development of young vines. Used as a mulch at low application rates, the spent mushroom compost conserves soil moisture, improves soil structure and improves conditions for plant growth and production.

**Spent Mushroom Compost** - the features of spent mushroom compost make it a quality source of organic matter for soil amendment:

- The disciplined compost production methods required for mushroom-growing ensure a consistent spent compost which has a predictable quality from season to season.
- The mushroom compost is pasteurised prior to mushroom cropping and again once the compost is spent. This pasteurisation can assure freedom from plant pathogens and weed propagules.
- With a relatively low carbon to nitrogen ratio, the spent mushroom compost can be considered to have some nutrient value, making it particularly suited for soil incorporation prior to vineyard establishment.

**Vineyard Establishment** - results have demonstrated benefits in the establishment of newly planted vineyards where spent mushroom compost has been incorporated in the soil prior to planting. Young vines were 20% taller ten months after planting than control vines (Fig. 1). The taller vines had almost twice as much shoot growth above the height of the cordon wire, giving the grower more opportunity to establish the structure of the vines uniformly across the vineyard.

![Figure 1 – Height of young vines ten months after planting in soil amended with spent mushroom compost](image)

**Yield and Quality**

Results have demonstrated opportunities to reduce irrigation while maintaining crop yield. In a trial with spent mushroom compost as a mulch under Shiraz vines, there were 20% more bunches at the first harvest after application, and a 30% increase in yield at the second harvest (Fig. 2), due largely to a 25% increase in bunch number (Fig. 3).
Bunch and berry size were not changed and juice pH and titratable acidity were not significantly affected by the spent mushroom compost. Juice sugar was reduced by 5%, confirming the need to adapt irrigation schedules when mulches are introduced into vineyard management practices.

Figure 2 – Yield of Shiraz vines with spent mushroom compost as a mulch

Figure 3 – Bunch number on Shiraz vines with spent mushroom compost as a mulch

**Water Saving** - measurements of soil moisture conducted in early spring showed there was 30% more winter rainfall stored in the topsoil under a mulch of spent mushroom compost. The surface mulch has been important in conserving winter and spring rainfall for use by the vines.

Figure 4 – Soil moisture increased with spent mushroom compost as a mulch undervine
**Water-Infiltration** - twelve months after application of spent mushroom compost as a mulch undervine, the rate of water-infiltration into the soil had increased by 40% (Fig. 5). Improved interception of rainfall provides good quality water, stored in the soil, and reduces reliance on supplementary irrigation.

![Infiltration rate in vineyard soil with spent mushroom compost as a mulch](image)

*Fig. 5 – Infiltration rate in vineyard soil with spent mushroom compost as a mulch*

The improved soil-water properties can be linked with higher earthworm populations. Increased earthworm activity, in response to the added ‘food’ from the spent mushroom compost, has resulted in improved infiltration.

**Earthworm Activity** - earthworm burrows intercept rainfall and irrigation water, reducing runoff and erosion, and can assist with the movement of water and nutrients into the rootzone. Earthworm activity also reduces soil-strength at depths where compacted layers often limit root growth.

With spent mushroom compost as a mulch, earthworm numbers increased by 40% (Fig. 6) and biomass increased 60% (Fig. 7). The activity of earthworms in the mulch just twelve months after application indicates that spent mushroom compost is a source of organic matter which can be safely used safely in close contact with plant roots.

![Increased earthworm activity with spent mushroom compost as a mulch undervine](image)

*Fig. 6 – Increased earthworm activity with spent mushroom compost as a mulch undervine*
Spent Mushroom Compost for Vineyards – field trials have demonstrated how the compost can be used for soil and water management:

- Spent mushroom compost can be used as a quality source of organic matter for soil incorporation prior to vineyard establishment. Applications 50-75mm deep, applied 500mm wide along the vine row (80-120m³/ha) can be cultivated into the soil to a depth of 200-250mm, to give a concentration in the soil of around 20-25%.
- Spent mushroom compost can be used at low application rates as a soil conditioner and mulch. Depths up to 50mm (80m³/ha) will provide for significant savings in irrigation, and improve soil structure. Applications should not exceed 50mm deep, to discourage root growth in the mulch above the soil surface.
- Using specialised compost spreaders, spreading contractors can readily apply the spent mushroom compost to vineyard soils.

Spent mushroom compost is a quality source of organic matter for improved vineyard soil management. Its consistency and freedom from plant pathogens and weed propagules make it a premium alternative, particularly suited for soil incorporation.

Extra Reading

Composted 'green-organics' from domestic collections and timber-milling residues was spread on the soil surface under trees and vines, and incorporated in the soil prior to the planting of vegetables.

Trials have been established with apples, cauliflowers, potatoes, mandarins, nectarines, plums and wine and table-grapes. Measurements on plants, at critical stages of growth and soil properties, have continued over eighteen months.

Yields and quality have been recorded for selected crops, and related to the effects of the compost on soil-structure and water-holding. The benefits of the compost have been linked to the effects of the organic-matter on earthworms, infiltration and soil strength.

These studies demonstrate the value of composted wastes for water-conservation and weed-control, and offer opportunities for improved plant growth and yields and options to better manage quality.

**Aims**

With a concern for the environment, the primary aims of the field studies were to reduce waste to landfill while improving the efficiency of agriculture. It is anticipated that developing credible markets for processed wastes will also provide employment within the region.

An extension program within local communities has communicated the outcomes of the field-trials to primary producers, and has provided data which can now be used more widely for education and training.

**Plant Growth**

Within six months, significant increases in growth were recorded on trees which had been mulched. With young vines, trunk-diameter was 20% higher where the compost had been spread on the surface under the trees (Fig. 1).

![Graph showing increase in trunk diameter](image)

Similar responses to the mulch were recorded with additional growth of nectarines and plums, and with young apples.

Trunk-diameter provides a useful measure of plant-growth. With sufficient measurements, differences related to the soil-treatments may be obvious within several months. The increased trunk-diameter indicates a more rapid development of young plants and improved performance of established trees and vines.

There was a small increase with the vermicompost alone, and a significantly greater increase in trunk-diameter with the compost mulch (Fig. 2). With the combination of both the worm-worked waste incorporated in the soil and the compost on the surface, the increase in trunk-diameter was more than 20% higher than the untreated (control) trees.

The more refined 'worm-worked wastes' were derived from animal manures and may have provided additional organic matter and nutrient in the root zone.

The increases due to the compost mulch suggest improved soil-conditions, favourable for plant-growth. In trials with compost in vineyards and orchards we have significantly increased water-use efficiency.

*Project proudly supported by*
Soil moisture was increased under the compost mulch, providing for considerable savings in irrigation water.

![Soil Moisture](image)

*Fig. 3 Soil moisture (0-30cm) with compost mulch.*

Under plums and nectarines, soil moisture in the upper 30cm was 10% higher, at the end of summer; less water was needed to maintain optimal soil-water conditions for plant-growth throughout the year (Fig. 3).

A surface mulch is important in conserving winter and spring rainfall. As well as improving soil water-holding properties, the compost clearly increases water-movement in soils.

**Water-Infiltration**

Within twelve months, soil water-infiltration had increased four-times, with the compost mulch on the surface (Fig. 4). Similar increases have now been demonstrated on a variety of soils, including coarse sands and heavy clays.

Improved interception of rainfall provides good quality water, stored in the soil, and reduces reliance on supplementary irrigation.

![Infiltration](image)

*Fig. 4 Water infiltration, with compost mulch.*

The improved soil-water properties are often linked with higher earthworm populations. Increased earthworm activity, in response to the added ‘food’ from a compost mulch results in improved infiltration.

**Earthworm activity**

Encouraging earthworms with organic matter is now well-established in the management of broadacre crops, where conservation of crop-residues has been important in developing sustainable agriculture. Similar responses can be expected with organic matter and earthworms in intensive horticulture.

![Earthworm Biomass](image)

*Fig. 5 Earthworm activity with compost mulch.*

We have consistently shown beneficial effects of organic wastes on earthworm activity. Within twelve months, earthworm populations have increased up to four times in the soil under mulch (Fig. 5).

Additional organic matter, which stimulates earthworms and other biological activity near the surface, also encourages root growth in the upper soil.

Earthworm burrowing reduces soil-strength at depths, where compacted layers often limit root growth, therefore root penetration is enhanced.

**Soil Strength**

Within twelve months, significant reductions in soil-strength were demonstrated under newly-planted apples. Improved conditions for root-growth have also been shown in soil under plums, pears, cherries, apples and nectarines.

Soil-strength has been similarly reduced, to a greater depth, under established vines (Fig. 6a). With the compost mulch on the surface, soil-resistance in the vineyard is reduced below the levels considered critical for root-penetration.

![Soil Strength](image)

*Fig. 6a Penetrometer resistance in vineyard soil.*

Penetrometer-resistance was measured, at 10cm depth intervals, in soil under mandarins. Within twelve months, compost mulch on the surface had significantly reduced soil-strength. This was related to the depth of the mulch. With 50cm of compost, penetrometer resistance was reduced by 30% at 30cm in the soil (Fig. 6b).

The response may be even more rapid where earthworms are abundant. Earthworm burrows intercept rainfall and irrigation water, reducing runoff and erosion, and can assist...
with the movement of water and nutrients into the rootzone. Field-trials have shown that, with a surface mulch, earthworms transport organic matter and surface-applied soil-amendments into the soil, around the roots of established trees and vines.

![Soil Strength (Mpa)](image)

*Fig. 6b Penetrometer resistance in orchard soil.*

With new plantings, it is possible to use earthworms to speed up the mixing and incorporation of lime and gypsum into the rootzone. And with improved aeration around the roots, the earthworm activity promotes plant-growth.

**Yields**

Yields of table-grapes, four months after compost mulch application, had increased significantly, with improved berry-size and increased export value.

![Grape Yields (kg/vine)](image)

*Fig. 7a Yields of table-grapes, with compost mulch.*

The higher grape yields were associated with higher rates of mulch, increasing by more than 15% with 100mm of compost undervine (Fig. 7a).

Compost was also mixed in the soil prior to the planting of cauliflowers. Harvest yields indicated that yields were increased 5% with lower rates of compost (Fig. 7b).

With compost incorporated in the soil, the yield of cauliflowers suited for the local market increased, but with the higher rates of compost there was a decrease in the export quality cauliflowers.

A similar response to compost mixed in the soil was observed with potatoes; at the highest compost rate, overall yields decreased and the proportion of 'rejects' increased. The degree of the compost processing and the rate of organic matter added to the soil appears to be critical.

**Cautions with Compost**

The field-trials have highlighted the importance of appropriate compost rates, particularly when the organic matter is incorporated in the soil. With vegetables, optimal yield responses corresponded with the lower rates of compost (see Fig 7b).

![Cauliflower Yields (kg)](image)

*Fig. 7b - Yields of cauliflowers, with compost in soil.*

Although the additional organic matter in soil may improve water-holding, this may not compensate for the possible nutrient-drawdown with compost which is inadequately processed.

Compost maturity and the depth of the surface covering may also influence the effects of the mulch on soil biota. In vineyard trials, the added organic matter in the compost-mulch significantly increased earthworm activity in the soil below (Fig. 8a).

![Earthworm Density (nos/m^2)](image)

*Fig. 8a - Earthworms under compost mulch in vineyard.*

Earthworm species identified during sampling included *Aporrectodea caliginosa*, *Aporrectodea trapezoides*, *Megascolia dubia* and *Oedomeris cyanosoma*. These earthworms have been reported widely in crops, pastures, orchards and gardens in southern Australia (Abbott 1982, 1985).

Earthworm numbers were highest with 25mm of mulch but were reduced as the depth of mulch was increased to 100mm. (See Fig 8a)
With increasing mulch depth, there were fewer earthworms in the soil and increasing numbers living above-ground in the mulch.

In this vineyard which was dependent largely on rainfall, the soil was drier under the deeper mulch; with increasing mulch soil-moisture was reduced up to 20% (Fig. 8b).

<table>
<thead>
<tr>
<th>Soil Moisture % (0-10cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control 0cm</td>
</tr>
<tr>
<td>30</td>
</tr>
</tbody>
</table>

A deep layer of fine organic material is likely to be highly absorptive, and can reduce the movement of water into the soil below. Both the depth and the particle-size of a surface mulch will be critical for optimal plant performance.

Mulch depth may be used to modify soil conditions. An appropriate depth can now be prescribed to reduce fluctuations in soil-moisture and temperature. In addition, a suitable grade of surface mulch can be used to reduce the need for herbicides for weed-control.

**Economics**

We consider that a mix of coarse and fine 'green-organics' compost is most appropriate for a surface mulch - the finer fraction is readily incorporated by earthworms in the soil - the coarser materials will continue to provide protection for the surface. We expect that residues from 5cm deep mulch will continue to provide significant benefits to vineyard and orchard soils, without reapplication for at least 4-5 years.

An appropriate 'grade' of compost for new plantings is available from 'green-organics' processors. This should conform to Australian Standards AS4454. With prices ranging from $20/m³, 5cm of mulch could be spread 50cm wide in vineyards for $2000/ha.

**The South West (WA) trials have clearly shown that compost mulches have significant benefits in horticulture, with improved plant growth and marked efficiencies in water and weed management. These studies complement other field-trials which confirm the value of composts for commercial horticulture.**

**Extra Reading ...**


**Acknowledgements ...**

The studies were supported by the South West Development Commission and the Western Australian Department of Industry and Technology. Field-trials were established and monitored by John Buckfield & Katie Webster (CSIRO / EcoResearch) and Bob Paulin (Agriculture WA).

Particular thanks for the success of the project are due to Alan Cross (SWDC) and Mark Pagamin (Landcare). Composted materials were generously provided by Bill Gifford and Robin Malatesta (Malatesta Green-Organics). We have appreciated the enthusiastic cooperation of growers involved in the research.
### Cabernet Sauvignon Trial Layout

<table>
<thead>
<tr>
<th>Row</th>
<th>26</th>
<th>27</th>
<th>28</th>
<th>29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot 1</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2 panels</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot 2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2 panels</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot 3</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2 panels</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot 4</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2 panels</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>buffer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottom of Slope</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0 = control  
1 = 50mm spent mushroom compost  
2 = 500mm straw  
3 = 50mm compost + 500mm straw

**NOTE - treatments in this trial differ from the original layout**  
*The trial has an extra control plot and is missing a straw plot*
Semillion Sampling Plan

<table>
<thead>
<tr>
<th>Row 62</th>
<th>Row 63</th>
<th>Row 64</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot 3</td>
<td>0</td>
<td>1 Panel</td>
</tr>
<tr>
<td></td>
<td>1 Panel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 Panel</td>
<td></td>
</tr>
<tr>
<td>Plot 3</td>
<td>1 Panel</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Panel</td>
</tr>
<tr>
<td>Plot 3</td>
<td>1 Panel</td>
<td></td>
</tr>
<tr>
<td>Plot 2</td>
<td>0 Panel</td>
<td>2 Panel</td>
</tr>
<tr>
<td>Plot 2</td>
<td></td>
<td>1 Panel</td>
</tr>
<tr>
<td>Plot 1</td>
<td>0 Panel</td>
<td>1 Panel</td>
</tr>
<tr>
<td>Plot 1</td>
<td></td>
<td>2 Panel</td>
</tr>
<tr>
<td>Plot 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>buffer</td>
</tr>
</tbody>
</table>

Bottom of Slope

0 = control
1 = 50mm spent mushroom compost
2 = 500mm straw

John Buckerfield & Katie Webster
EcoResearch
Spent Mushroom Compost for Viticulture
Field Evaluation & Market Development
## Shiraz Trial

<table>
<thead>
<tr>
<th>Plot</th>
<th>Row 23</th>
<th>Row 22</th>
<th>Row 21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot 6</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Plot 5</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Plot 4</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Plot 3</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Plot 2</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Plot 1</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

0.5m 0.5m 0.5m

**ROADWAY**

0 = control  
1 = 50mm spent mushroom compost  
2 = 500mm straw

---

John Buckerfield & Katie Webster  
*EcoResearch*

Spent Mushroom Compost for Viticulture  
Field Evaluation & Market Development
### Incorporation Trial

<table>
<thead>
<tr>
<th>Plot</th>
<th>Row 18</th>
<th>Row 19</th>
<th>Row 20</th>
<th>Row 21</th>
<th>Row 22</th>
<th>Row 23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot 3</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Plot 2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Plot 1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Plot 0</td>
<td>0.5m</td>
<td>0.5m</td>
<td>0.5m</td>
<td>0.5m</td>
<td>0.5m</td>
<td>0.5m</td>
</tr>
</tbody>
</table>

---

**Top of Slope**

0 = control  
1 = 50mm spent mushroom compost  
2 = 50mm green-organics based compost

---

John Buckerfield & Katie Webster  
*EcoResearch*  
Spent Mushroom Compost for Viticulture  
Field Evaluation & Market Development
Testing soil amendments in vineyards
The “with and without” trial layout

Katie Webster & John Buckerfield