KEY MESSAGES

✓ ‘Organic’ means that amendments originate from living organisms (plants or animals), now dead and decomposed.
✓ Organic amendments are mostly applied pre-planting of cash or cover crops, and always contain carbon and all major nutrients (N, P, S and K).
✓ The main expected benefit from using organic amendments is a positive effect on general soil health and soil biology as well as disease suppression.
✓ The effect on the soil and crop will vary due to the type of amendment, the crop and production environment, time, volume and frequency of use, as well as other management inputs.
✓ It’s important to consider the risks, food safety and quality, and costs in deciding what organic amendment to use.
✓ There are a range of future research, development and extension needs relating to soil biology, soil chemistry and other factors such as regulation, biosecurity and quality assurance.

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WHAT ARE ORGANIC SOIL AMENDMENTS?

‘Organic’ means that amendments originate from living organisms (plants or animals), now dead and decomposed. They come from a range of sources, including farm waste, recycled household wastes, manures, municipal green waste and sludges (biosolids). Fresh produce and food processing waste, some manufacturing wastes and sludges are also used as (part of) organic soil amendments (soil conditioners, organic fertilisers). The composition, maturity, stability, quality (for agriculture), inherent risks, benefits and function of different forms of organic amendments including those categorised as ‘compost’ varies greatly depending on feedstocks and further treatment. Amounts of nutrients contained in different types of amendments are highly...
variable. In many cases, nutrient levels vary from batch to batch. Usually, the higher the level of processing or manufacturing and maturity of composts, the more consistent the nutrient levels. Often nutrients are added to achieve a desired range and balance.

Organic soil amendments are not necessarily suitable for the production of certified organic vegetables, unless this is explicitly stated, and certification is available.

**Composition**

Organic amendments contain the following components in different forms and combinations/levels:

- Carbon (always) – this may cause a drawdown of nitrogen
- All major nutrients (always N, P, S and K) – to be included in the nutrient budget for the crop
- Usually some trace element nutrients - to be included in the nutrient budget for the crop
- Potentially beneficial microbes
- Potentially contaminants such as heavy metals, salts, pesticide residues
- Potentially plant, animal or human pathogens
- Potentially visible or very small foreign objects like glass, metal or plastic.

**WHY ARE GROWERS INTERESTED IN SOIL AMENDMENTS / CONDITIONERS?**

The following arguments have been presented by growers and agronomists:

- General soil health improvement
- Soil biology improvement
- Improve or maintain organic carbon levels
- Manage soilborne diseases
- Replace some mineral fertilisers
- Improve water holding capacity.

The main expectation from organic amendments is a positive effect on general soil health and soil biology as well as disease suppression. There is an expectation that increased, or more balanced soil life can be achieved via amendments and that they may provide productivity and sustainability improvements.

**HOW ARE ORGANIC AMENDMENTS USED?**

Organic amendments are mostly applied pre-planting of cash or cover crops. They are broadcast over the entire paddock, on beds only and worked into the soil or band placed. They may remain on the soil surface to suppress weeds or reduce the effect of sandblasting. Sometimes amendments are applied post planting, but side dressing is usually not feasible unless the amendment is pelletised or part of a fertiliser compound or mix. Some liquid amendments can be applied post planting.

Depending the origin, treatment and intended use of soil amendments from recycled organics, regulations or codes of practice apply to their use. The objective of regulations is to protect the environment from eutrophication or contamination, and people and or animals from diseases and exposure to toxic substances (Food Safety). Specific regulatory and food safety considerations are presented in a separate section of this paper.

Appendix 1 includes a glossary describing types of soil amendments used in agriculture.

**WHAT EFFECT DO ORGANIC AMENDMENTS HAVE ON SOILS AND CROPS?**

The knowledge scan and review of the effect of organic amendments on soils and vegetable crops found that effects vary. Outcomes depend on many factors such as:

- The type of amendment
• The crop and its production environment (soil, weather, disease pressure)
• The timing, volume and frequency of use
• Other crop management inputs, their type, and frequency of use.

**Effect on soils**
Apart from changing levels of abovementioned components in the soil, amendments will have an effect on a range of soil properties. The magnitude of the effect depends on these factors. The main soil properties affected include:
1. pH and EC / nutrient availability
2. Sodicity / dispersibility / slaking
3. Infiltration / wettability, water holding capacity and permeability / drainage
4. Texture / porosity / bulk density
5. Biological activity and composition / respiration / nutrient cycling.

The indicators under dot points 1 and 2 can be checked relatively easily via conventional soil testing. The physical (dot points 3 and 4) and biological attributes (dot point 5) need to be measured via specialised tests.

Land managers may notice positive effects on:
• Soil workability
• Irrigation needs
• Fertiliser needs
• Drainage after heavy rain
• Level of worms and critters.

**Effects on crops**
Effects of organic amendments on crops depend on how, how much, where and when they are used. The effects may be amplified, reduced or negated through other management inputs and activities such as tillage, nutrition, irrigation, pest, weed and disease control.

Positive effects reported by researchers and observed by land managers are:
• Pest, disease and/or weed suppression, reduced pesticide use
• Reduced fertiliser inputs
• Improved rooting depth and root distribution.

**Rates of organic amendments**
Given the multitude of organic amendments, reasons for their use, crops and production systems, a one-size-fits all approach for rates, timings and placements cannot be recommended. Rates and use patterns have to be site specific and the following needs to be considered:
• Nutrient content as part of an overall nutrient budget and plans for repeat applications
• Product quality / purity and consistency
• Soil conditions / fertility
• C/N ratio
• Timing of application and planting
• Type of application and placement (e.g. banding vs broadcast)
• Risks such as leaching into waterways
• Available spreading equipment.

**SPECIFIC CONSIDERATIONS**
**Deciding what organic amendment to use**
Three main points you should consider when selecting an organic amendment for use are:
• Is it young or mature? This tells you how long the amendment is likely to stay in soils and when and when not to use it in your production system.
• Did it have a lot of nitrogen-rich input or carbon-rich input? This gives you an indication of the nutrients (in particular nitrogen) that will be immediately available to the production system to allow adjustment of other farm inputs such as fertilisers.
• What are the predominant particle sizes? This provides guidance on how to use the compost, such as small particle size being appropriate for incorporation, whereas large particles are more appropriate for mulching.

Risks
The main risks and concerns with organic amendments are associated with:
• Poorly made products with unacceptable levels of impurities and contamination. Feedstocks used to produce amendments can be a source of heavy metals, pathogens, weed seeds, plastics and other waste material. Inappropriate and insufficient management during manufacturing can lead to amendment products with unacceptable levels of contaminants.
• Consistency of the products. Feedstock availability can vary across the year resulting in some organic amendment manufacturers unable to provide a consistent line of product all year round.
• Inappropriate matching of a compost product for the intended use. Product maturity and timing of application for vegetable production is very important. A young active carbon-based soil amendment product applied at planting can cause microbes to draw nitrogen from the soil to break down the compost and will starve the plants of nutrients.

Other risk considerations for any grower is electrical conductivity (EC) and pH of organic amendment products. Most amendments have a neutral to slightly alkaline pH, however this can vary. Amendments tend to have EC values in excess of those in soils.

To avoid these risks, organic amendments should be sourced from reputable suppliers. The highest form of guarantee is sourcing product from suppliers who are certified. Certification means the compost is produced in accordance with Australian Standard (AS) 4454-2012.

Food safety and quality
A simple decision tree to help guide the use of soil amendments within your program is available. Key considerations to note with using amendments under Freshcare certification include:
• Certified compost (AS 4454-2012) can be used without restriction
• Where composting treatment cannot be verified, it should be managed as an untreated manure
• Untreated manures (including soil amendments mixed with untreated manures) need to have a minimum period pass between application and harvest, this is at least 90 days if the soil potentially contacts the harvestable part of produce that may be eaten uncooked.

Cost of organic amendments
The costs associated with amendments can be determined by several factors. This includes:
• Type and quality of the material
• Water content of the material
• Freight costs based on distance
• Spreading/incorporation costs, which depend on:
  • application rates
  • type of compost
  • machinery required – travelling time
  • scale of the work.

It is important to also consider labour and financial costs associated with other practices that may need to change in conjunction with amendment application, such as tillage, nutrition, irrigation and crop protection requirements.

This project has been funded by Hort Innovation using the vegetable research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.
RESEARCH, DEVELOPMENT AND EXTENSION NEEDS

Soil biology

- A better understanding and predictability of the role of soil biology (e.g. certain groups of soil life) in processes such as availability and cycling of nutrients and suppression of disease.
- Improved understanding / classification of major groups of soil amendments, soil conditioners, microbial ‘inoculants’, in solid and liquid form, in different production environments, which claim to positively influence soil biology and through that, physical and chemical soil properties, resulting in crop responses (yield, quality, pest and disease tolerance or suppression).
- How can abovementioned soil and crop responses to ‘biologically active inputs’ be best tested in a manner that allows comparisons and the selection of ‘fit for purpose’ inputs?
- Better understanding of the contribution that soil biology may make to healthy, nutritious food.

Soil chemistry

Soil chemistry research currently receives the largest proportion of soils RD&E funding. There is a strong focus on soil nutrition with fertiliser being 15-20 percent of input costs for many producers. Research gaps include:

- New ‘stable’ organic amendment products such as struvite (nutrients extracted from organic waste), composts and biochar with known composition and relatively predictable effect on soil fertility with the potential to reduce input costs.
- Better standards and descriptions and full life cycle analysis is needed for some existing and all new soil amendment type products.

Other needs

- Addressing biosecurity issue for import and transport of some organic amendments.
- Quality assurance systems for biologically active soil amendment products.
- Consistent analytical techniques for product and soil biological testing (e.g. ASPAC accreditation of methods used in testing).
- An improved capacity for the interpretation of soil and plant tests (chemical, biological and physical) in a production systems context.
- An improved capacity for using monitoring data to make decisions about soil and crop management inputs.
- Better predictability of effects of soil amendments given certain monitoring results.
- Improved extension of soil biology information to better understand how management practices might be adjusted to improve the availability of nutrients and reduce the impact of pests and diseases. Soilborne pests and diseases should be considered part of soil life, not a separate discipline.
- National standards for metagenomics testing of soils.

The study of genetic material recovered directly from soil samples (metagenomics) and multidisciplinary approaches may provide information to help link soil and crop management actions to functional soil properties. For example, operations and inputs could then be selected and timed to favour beneficial soil organisms or to suppress disease.

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APPENDIX 1: GLOSSARY

The following table lists the main organic amendments used on farms as soil conditioners. It does not describe the multitude of highly processed, altered manufactured solids (e.g. based on pelleted animal manures and composts), mainly used as fertilisers or liquid products containing humic or fulvic acids, microbes and/or seaweed extracts and/or nutrients.

<table>
<thead>
<tr>
<th>MATERIAL / TERM</th>
<th>DESCRIPTION / SPECIFICATION (AS AVAILABLE)</th>
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<tbody>
<tr>
<td><strong>GENERAL</strong></td>
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<tr>
<td>Inorganic fertiliser</td>
<td>Materials of natural and synthetic origin that are applied to soils or to plants (usually the canopy in liquid form) to supply one or more plant nutrients essential to plant growth or alter the chemical, biological and physical condition of soils (liming materials, gypsum).</td>
</tr>
<tr>
<td>Organic materials (Organics)</td>
<td>Chemical compounds existing in or derived from plants or animals, and other compounds of carbon.</td>
</tr>
<tr>
<td>Organic (or natural) soil amendments also called Soil conditioner, Soil improver, Soil additive, Organic fertiliser</td>
<td>Organic (biological) inputs to soils used to improve the biological, chemical or physical condition of the soil. The inputs can be in solid, sludge/slurry or liquid form. Composted or pasteurised organic materials including vermicast, manures and mushroom substrate that are suitable for adding to soils. This includes processed/manufactured solids and liquids and excludes polymers that do not biodegrade such as plastics, rubbers and coatings. Solid soil conditioners have not more than 20% by mass of particles with a maximum size above 16 mm. Products with greater particle size are used as mulches.</td>
</tr>
<tr>
<td><strong>CATEGORIES OF ORGANIC or NATURAL SOIL AMENDMENTS</strong></td>
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<tr>
<td>Raw natural material obtained from natural deposits</td>
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<tr>
<td>Peat</td>
<td>Accumulation of decomposed vegetation or organic matter. Degree of decomposition varies depending on the origin of the peat and its age. Peats are used as a soil conditioner or substrate. Nutrient rich peat bogs or moors are developed from wetland vegetation including small trees that decayed in pools of stagnant water connected to groundwater. Sphagnum peat consists of moss residues that have accumulated on acid soils with poor drainage or on peat bogs, they sit above the groundwater level and are low in nutrients.</td>
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<tr>
<td>Brown coal</td>
<td>Brown coal and products made from brown coal used as a carbon rich soil conditioner. Some brown coal products have been enriched with nutrients to mimic the composition of humus.</td>
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<tr>
<td>Raw waste organics</td>
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<tr>
<td>Manures</td>
<td>Animal excrement (urine, dung) which may contain various amounts of bedding such as sawdust, tree bark or straw.</td>
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<tr>
<td>Manure slurry</td>
<td>Animal excrement and water with only small amounts of bedding.</td>
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<tr>
<td>Waste organics, bio-waste (biodegradable waste)</td>
<td>Any waste that is suitable for undergoing anaerobic or aerobic decomposition (= composting), such as food and organic agricultural waste, paper, cardboard and waste from forestry (sawdust, wood chips) or municipal parks (tree cuttings, branches, grass, leaves – with the exception of street sweepings), and other wood waste not treated with heavy metals, pesticides or organic compounds, textiles made from natural fibres.</td>
</tr>
<tr>
<td>Municipal solid waste</td>
<td>Solid waste from households that is not necessarily made up entirely of organic materials. It may contain minerals or processed/manufactured solids.</td>
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<tr>
<td>MATERIAL / TERM</td>
<td>DESCRIPTION / SPECIFICATION (AS AVAILABLE)</td>
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<tr>
<td>Garden/green waste</td>
<td>Waste entirely made up of plant/organic materials (no minerals or processed/manufactured solids).</td>
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<tr>
<td><strong>Biosolids</strong></td>
<td>Organic solids or sludges 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 wastewater solids. The solids content in biosolids should be equal to or greater than 0.5% weight by volume (w/v). The solids component of biosolids is rich in organic matter and essential plant nutrients such as nitrogen and phosphorus. Thus, biosolids can be used as input materials for compost production. The term biosolids does not include untreated wastewater sludges, industrial sludges or the product created via the high temperature incineration of sewage sludge. It should also be noted that many other solid waste materials are not classified as biosolids, e.g. animal manures, food processing or abattoir wastes, solid inorganic wastes, and untreated sewage or untreated wastes from septic systems/sullage wastes.</td>
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<tr>
<td>Treated, processed, or refined waste organics</td>
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<tr>
<td>Pasteurised/sanitised organic material</td>
<td>An organic product that has undergone pasteurisation but is relatively immature and lacking in stability. Pasteurisation is a process whereby organic material is treated to significantly reduce the numbers of plant and animal pathogens and plant propagules.</td>
</tr>
<tr>
<td><strong>Composts</strong></td>
<td>All types of recycled, organic materials, which are completely decomposed (biodegraded, rotted, humified) so that they are amorphous i.e. without a cellular structure characteristic of plants or animals. During the correct composting process, organic materials are pasteurised, microbially transformed and stabilised under aerobic and thermophilic conditions for a period of not less than 6 weeks¹. Composts are destined for use as soil amendment, either as a fertiliser because of their nutrient content, and or as soil conditioner because of their positive effect on soil structure, biology and chemistry (in addition to the nutrient value). The Australian Standard (AS) 4454-2012 applies to composts, soils conditioners and mulches; it includes specified levels of maturity (pasteurisation and stabilisation) requirements including their relationship to quality assurance schemes for agricultural produce. Compost maturity The degree of decomposition, pasteurisation and stabilisation at which compost is not phytotoxic or exerts negligible phytotoxicity in any plant growing situation when used as directed. Compost stability The degree of decomposition at which the rate of biological activity under conditions favourable for aerobic biodegradation has slowed and microbial respiration will not resurge under altered conditions, such as manipulation of moisture and oxygen levels or temperature.</td>
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<tr>
<td>Blood and bone</td>
<td>Dried animal blood mixed with bone meal.</td>
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<tr>
<td>Vermicompost</td>
<td>Material that is egested from earthworms as casts then further decomposed and matured in a vermicomposting system.</td>
</tr>
<tr>
<td>Mulch</td>
<td>Any pasteurised or composted organic product (excluding polymers which do not biodegrade such as plastics, rubbers 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 16mm. Mulch has at least 70% by mass of its particles with a maximum size of greater than 16mm.</td>
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<tr>
<td>Biochar</td>
<td>Biochar is charcoal made from organic materials via pyrolysis. It is a stable solid, rich in carbon, and can endure in soils for long periods.</td>
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¹ Recycled Organics Unit 2007; Information sheet No. 3-6 Biosolids guidelines: Raw materials and compost product quality
## Related materials and terms

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<tr>
<td>Organic bio-stimulants</td>
<td>The definition is still evolving: any substance or microorganism, in the form in which it is supplied to plants, seeds or the root environment with the intention to stimulate natural processes of plants benefiting nutrient use efficiency and/or tolerance to abiotic stress, regardless of its nutrient content, or any combination of such substances and/or microorganisms intended for this use.</td>
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<tr>
<td>Compost extract</td>
<td>The filtered product of compost (including vermicompost) mixed with any solvent (usually water), but not fermented. This term has been used in the past to define water extracts prepared using a very wide range of different methods. In the past, the terms “compost extract”, “watery fermented compost extract”, “amended extract”, “compost steepage” and “compost slurry” have all been used to refer to non-aerated fermentations. “Compost extract”, “watery fermented compost extract” and “steepages” are approximate synonyms defined as a 1:5 to 1:10 (v:v) ratio of compost to water that is fermented without stirring at room temperature for a defined length of time. “Amended extracts” are compost extracts that have been fermented with the addition of specific nutrients or microorganisms prior to application.</td>
</tr>
<tr>
<td>Compost tea</td>
<td>The product of showering recirculated water through a porous bag of compost suspended over an open tank with the intention of maintaining aerobic conditions. The product of this method has also been termed “aerated compost tea” and “organic tea”. In the past, the term “compost tea” has not always been associated with an aerated fermentation process. It is important to distinguish between compost teas prepared using aerated and non-aerated processes, therefore the terms aerated compost tea (ACT) and non aerated compost tea (NCT) are used in this review to refer to the two dominant compost fermentation methods. ACT refers to any method in which the water extract is actively aerated during the fermentation process. NCT refers to methods where the water extract is not aerated or receives minimal aeration during fermentation apart from during the initial mixing.</td>
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