Compost specifications for horticulture

Introduction

This document is one of a set of six specifications for the application of recycled organics in the following settings:

1. **Horticulture**
2. **Sporting fields and turf production**
3. **Compost blankets for erosion control**
4. **Biofilter establishment**
5. **Pastures**
6. **Landscaping.**

These specifications have incorporated the NSW Resource Recovery Orders (RROs) and Resource Recovery Exemptions (RREs) for compost and pasteurised garden organics which specify legal requirements in NSW under which it is permitted to use these recycled organic wastes on land. The conditions and limits stipulated in these regulations have been included. Note that the resource recovery orders and exemptions (RROs and RREs) only apply in NSW.

The basis of these specifications is Australian Standard AS 4454-2012 Composts, soil conditioners and mulches. This standard specifies the general physical and chemical characteristics of composted products that should be used as a minimum basis for selecting products. These specifications use AS4454 as the basis and recommend additional criteria where it is directly relevant to optimising performance.

These specifications provide guidance on the characteristics of composted recycled organics, and include information on:

- general characteristics and minimum acceptable contamination levels, for the six mentioned applications
- performance characteristics
- appropriate use and application recommendations.

These do not include specifications or details for other recycled organics products such as uncomposted manures, compost made with biosolids or solid or liquid food wastes.*

General Specifications

Many of the criteria listed in AS4454 are relevant to composts for horticultural applications, as they specify the basic suitability of compost for land applications. These characteristics apply equally to vegetable and orchard production systems.

Where horticultural activities are mixed with grazing of animals, generators and consumers of composts must ensure that they are meeting their responsibilities under the Biosecurity Regulation 2017 (clauses 37 and 38). Compost generated from animal material including food waste (such as from kerbside collected food and garden waste), animal manures, rendered products such as blood and bone, abattoir waste, grease trap waste, mixed food organics, and pet food are considered as restricted animal material (RAM[1]) and action under biosecurity legislation applies.

The general product specifications for composts to be used in horticulture are presented in Table 1.

* Composts made with biosolids are managed under the Biosolids Order and have particular conditions that may not be suitable for use under the scope of these brochures.

1 See DPI website **www.dpi.nsw.gov.au/about-us/legislation**

Table 1 General product characteristics for compost used for horticultural applications (Source: AS4454)

Characteristic	Unit	Target / typical range	Advice
pH $_{(1:5\ water)}$	pH units	Range 5.5 – 8.0	If >8.0 determine total CaCO3 content
Electrical Conductivity (EC)	dS/m	< 6	High EC may limit application rates
Organic Carbon	% dry matter	15 - 25	Generally higher organic carbon is preferable for composts of equivalent maturity
Carbon: Nitrogen Ratio	(C:N)	Typically 10:1 – 25:1	C:N is typically higher for mulches used in orchards, lower for composts incorporated into soil in vegetable production

Acceptable contamination levels

Composts used in horticulture should be as free as possible from all types of contamination. Compost not meeting the limits in Table 2 should be rejected due to possible environmental and human health risks. Most producers will supply a sample of their products if requested.

Table 2 Maximum acceptable level of contaminants for horticulture use

Biological Contamination				
Plant Propagules	Unit	Recommendation		
Viable Plant Propagules	Number	Nil after 21 Days		
Vermicast Sieve Test	% Volume	Nil after 21 days for the fraction ≥ 90% passing the 1.18 mm sieve		
Microbial Contaminant	Unit	AS4454 Limit[2]	RRO Limit[3]	Freshcare
E. coli	MPN/g or cfu/g	-	<100	<100
Salmonella	cfu/g	Absent in 50g	Absent in 25g	Absent in 25g
Faecal Coliforms	MPN/g	<1,000	<1,000	

Physical Contaminants			
Material	Unit	Recommended Limit	AS4454 limit[4]
Glass, Metal and Rigid Plastic > 2mm	% dry matter (dm) (w/w)	≤ 0.25	<0.5
Plastic - light, flexible or film > 5mm	% dm (w/w)	≤ 0.025	<0.05
Stones and Lumps of Clay	% dm (w/w)	≤ 2.5	<5

2 As specified in Australian Standard AS4454-2012

3 NSW Compost Order 2016

4 Compost Order 2016 and the Pasteurised Garden Organics (PGO) order both require these limits for rows 1 and 2. PGO Order at: **www.epa.nsw.gov.au**

Chemical Contaminants					
Heavy Metals	Unit	AS4454	Other Chemicals	Unit	AS4454
Arsenic	mg/kg	20	DDT/DDD/DDE	mg/kg	0.5
Cadmium	mg/kg	1	Aldrin	mg/kg	0.02
Boron	mg/kg	100	Dieldrin	mg/kg	0.02
Chromium	mg/kg	100	Chlordane	mg/kg	0.02
Copper	mg/kg	150	Heptachlor	mg/kg	0.02
Lead	mg/kg	100[5]	HCB	mg/kg	0.02
Mercury	mg/kg	1	Lindane	mg/kg	0.02
Nickel	mg/kg	60	BHC	mg/kg	0.02
Selenium	mg/kg	5	PCBs	mg/kg	0.2
Zinc	mg/kg	300			

Food safety requirements

Freshcare FSQ4[6] is the national food safety best practice quality standard for fresh fruit and vegetables.

There are slight differences between these thresholds for pathogens. If products comply with the RRO regulations in terms of pathogen loads, then they will be compliant with Freshcare.

Freshcare restricts the use of unpasteurised products, e.g. manures, where restrictions apply regarding the timing of application prior to harvest. To enable composts to be safely used and to satisfy Freshcare provisions, verified evidence of pasteurisation needs to be provided by the producer. Once provided, compost products can be used unrestricted.

Performance characteristics

Beyond the quality characteristics specified in AS4454 there are several more characteristics that impact upon compost performance in the field. These performance characteristics differ slightly with each type of application due to production and crop requirements and can also be modified and amended after the composting process to create 'fit-for-purpose' composts suited to specific uses. Table 3 provides recommendations for nutritional characteristics of composts designed for use in horticulture.

5 Note that this differs from AS4454 limit of 150mg/kg. Clause 43 of the Biosecurity Regulation 2017 sets 100mg/kg as the maximum allowed concentration for lead (Pb) in a fertiliser. Fertilisers include composts. Clause 44 of the Biosecurity Regulation 2017 also refers to label requirements on fertilisers that exceed 'trigger levels' for lead, cadmium and mercury of 20, 1 and 0.2mg/kg respectively. The label requirements advise that use of the product may result in the accumulation of those metals in the receiving soils. **legislation.nsw.gov.au**

6 **freshcare.com.au**

Table 3 Recommended characteristics for composts designed for use in horticulture

Characteristic	Unit	Typical range or desirable level	Advice for vegetable production	Advice for orchard production
pH (water 1:5)	pH units	5.5 - 8.0	Compost has a natural pH buffering effect due to the high organic matter content. This can counter-balance the acidifying effects of some fertilisers. Conduct soil test results and use higher pH or lime-amended compost for very acid soils and an unamended or lower pH compost for neutral to alkaline soils. This test will guide the choice of compost but is unlikely to be a limiting factor.	
Total CaCO3 Equivalent		6.5-7.5 Report only when pH>8	Soil pH >8 may be found in intensive vegetable production soils. Compost with pH < 7 is best used on soils with pH >8 as it can act as a pH buffer. Lime can be added to composts after production and prior to land application to increase the liming effect to correct an acid soil.	
Electrical Conductivity (EC)	dS/m	<6	If EC > 4 dS/m, check Sodium (Na) and Chloride (Cl) levels particularly where soil test shows salinity problem. High EC may limit application rates.	
Nitrogen - Total	% dry mass	>1.5% for composts claiming to be providing plant nutrition Typical range: 0.8 - 1.9	About 25-30% of total N in composts is likely to be available in the first year, and about 10% and 5% available in the subsequent 2nd and 3rd years. Therefore, 10 wet tonnes (at 50% moisture) of typical compost can contribute 8 -19 kg N which is approximately equivalent to 15 - 35 kg Urea. The remainder remains unavailable to plants in the long term. In colder climates, these proportions are reduced.	
			Composts with higher total N have a greater potential of releasing N over time thus providing a long-term source of N. Typical N requirement for vegetables is 150kg N/ha /crop.[7] As a guide, compost is unlikely to supply sufficient N, at least during periods of high N demand such as early seedling establishment.	Composted mulch applied at 75mm depth can provide between 25% and 95% of the total N requirements of the crop. This N is available slowly over time.
Nitrogen - Ammonium	mg/L in solution	<100 for mature composts Typical range: 10 - 200	Ammonium is a readily plant available form of nitrogen. Mature composts should have low levels of ammonium.	

7 Healthy soils for sustainable vegetable farms – Ute guide. AusVeg 2007.

Characteristic	Unit	Typical range or desirable level	Advice for vegetable production	Advice for orchard production
Nitrogen (N) – Nitrate	mg/ kg dry mass	>10 for composts claiming to be providing plant nutrition Typical range: 5-300	Nitrate nitrogen (NO3) is a readily plant available form of nitrogen. Mature composts should have high levels of nitrate. Generally, composts will rarely provide sufficient crop N without the compost being amended with additional N by including manures, biosolids or another high N source as inputs to the composting process.	Nitrate loading and availability over time can exceed requirements of fruit trees, leading to excessive vegetative growth, delayed or reduced fruiting and reduced fruit quality.
Phosphorus (P) – Total	% dry mass	>0.5 for composts claiming to be providing plant nutrition Typical range: 0.1 - 1.1	About 40% of the total P in compost will be available in the first year after application under different climate and soil types. Therefore, at 0.5% P content, 10 wet tonnes of compost (at 50% moisture) would contain 20 kg P. This would provide 8 kg of plant available P and be equivalent to 65 -90kg of super-phosphate. The availability in subsequent years is about 20% in the second year and 10% in the third year of compost application.	
			Typical total P requirement for vegetables is 80kgP/ha/ crop.[6] Compost with low P is desirable in soil with high P reserves (>150mg/kg). P may limit compost application rate, particularly if paddock history includes poultry manure application. Generally, application rates determined to satisfy crop N demands are sufficient to cover P requirements.	Composted mulch applied at 75mm depth can provide between 47% and 95% of the total P.
Phosphorus – Soluble	mg/L	>200 for compost claiming contribution to plant nutrition Typical range: 5 - 350	Soluble P contributes significantly to plant nutrition and the level is used to calculate compost application rate and nutrient budgeting. Generally, plant requirements for soluble P range from 10-50 mg/kg. Levels of soluble P in excess of this may leach from the soil and cause environmental issue in waterways. Compost with higher P needs to be used at lower rates in soil with high P to avoid this.	

Characteristic	Unit	Typical range or desirable level	Advice for vegetable production	Advice for orchard production
Potassium (K)	% dry mass	>0.8 for composts claiming to be providing plant nutrition Typical range: 0.5 - 1.0	About 80% of compost applied K will be available in the first year after application and the remaining K will be available in the second year after application. At 0.8% K content, 10 wet tonnes of compost would provide 28kg K. This would be approximately equivalent to 70kg potassium sulphate.	
			Typical K demand in vegetable crops is 80kg/ha/ crop[6]. High K levels in composts can limit application rates before the required crop N levels are reached. Guided by crop nutrient demand, it can be useful if the K levels in applied composts are low, to maximise compost use before K supply limits compost application rate.	Composted mulch applied at 75mm depth can provide between 85% and 95% of the total K requirements in the first year.
Sulphate/ Sulphur (S)	% dry mass	Typical level: >0.3	Sulphur is rarely a concern as a deficient nutrient except in sandy soils. Composts generally supply sufficient S to cover plant requirements. Over supply of S is rarely an issue and compost only contain elevated sulphur levels when feedstock contains high amounts.	
Sodium	% dry mass	Recommended level: <1	Some composts, in rare occasions, may have elevated levels of salts, particularly NaCl depending on feedstock. Lower sodium levels are preferable, particularly in areas with sub-soil salinity. Chloride levels also should be as low as possible. Compost with low chloride should be used on land with sub-soil salinity. Generally, sodium and chloride are not an issue when EC is low (<4 dS/m).	
Chloride	mg/ kg dry mass	Recommended level: <600		
Trace elements[8]			Composts can provide very useful levels of trace elements. These are generally immediately available in composts with neutral pH.	
Magnesium (Mg)	% dry mass	Typical range: 0.3- 0.6	Generally, fruit and vegetable requirements for Mg are 10-70 mg/kg to produce satisfactory yield. An application of 10 t/ha of compost can provide between 30-60kg/ha Mg.	
Zinc (Zn)	mg/ kg dry mass	Typical range: 170 - 300	AS4454 limits the amount of Zn in composts to 300 mg/kg. Most composts can supply adequate maintenance levels of Zn but compost Zn alone will not suffice in situations where there is Zn deficiency.	
Boron (B)	mg/ kg dry mass	Typical range: 8 - 26	Composts can contribute to B maintenance but will not supply sufficient B to overcome deficiency. AS4454 limits B concentrations to 100mg/kg. In low rainfall areas with alkaline soils B toxicity may limit compost application to low rates.	

8 NSW DPI 2005, Apple and Pear Primefact. No.85, NSW DPI 2002, Citrus Nutrition. Agfact no.H2.3.11, Hochmuth et al. 2012.

Characteristic	Unit	Typical range or desirable level	Advice for vegetable production	Advice for orchard production
Manganese (Mn)	mg/ kg dry mass	Typical range: 350 - 550	Composts can contribute significantly to Mn demands. In acidic, waterlogged soils, toxicity may occur when soil Mn >20 mg/kg.[9] Composts high in Mn need to be used with caution in these soils.	
Calcium (Ca)	% dry mass	Typical range: 1 - 3.8	At the higher end of the range composts are a good source of Ca. If Ca deficiency is a known problem additional lime blended with the compost will increase both available Ca and pH.	
Iron (Fe)	mg/ kg dry mass	Typical range: 8,000-12,000 (0.8-1.2%)	Provided the soil pH is not alkaline, soils generally have abundant levels of iron (around 2.5%) and composts do not significantly add to the availability of Fe, as much of the Fe is associated with organic matter and not readily available. Fe toxicity is rarely an issue except in acid waterlogged soils.	
Copper (Cu)	mg/ kg dry mass	Typical range: 40 - 55	Composts can meet Cu demands (0.3-0.5 mg/kg)[8] at application rates of 5-10 t/ha and may rectify Cu deficiency. High application (>20t/ha) rates may result in Cu levels beyond plant requirements. Soil Cu levels above 100mg/kg can cause toxicity symptoms in some sensitive crops, particularly in acid soils.	
Molybdenum (Mo)	mg/ kg dry mass	Typical range: 1 - 4	The sufficiency range for Mo is 0.5-5.0 mg/kg for a range of fruit and vegetable crops. Composts can provide sufficient Mo provided soil pH is neutral to alkaline. Mo becomes unavailable in acid soils.	
Physical characteristics				
Particle size		70- 80% < 16mm 10- 20% > 25mm	80% < 16mm 20% > 25mm As clay content of soil increases the % of coarse particles should increase	15% < 16 mm; min 70% > 16 mm; max 5% > 25 mm
Stability and Maturity		See Table 4	Pass 4 maturity tests	

9 Soil Sense. NSW Agriculture 2000. (Reference: *Soil Analysis- An Interpretation Manual. Peverill, K.I., L.A. Sparrow and D.J. Reuter, CSIRO 1999,* unless otherwise stated)

Compost maturity and stability

The maturity and stability of composted products impacts the performance of the product once it is placed on the soil surface or incorporated. If a compost is applied before it is biologically stable and mature the composting process can continue in the field.

The maturity of compost refers to the degree of phytotoxicity. Immature compost will contain more growth-inhibiting compounds that are associated with the early stages of the composting process than mature compost. More mature compost exhibits lower levels of phytotoxicity and a higher degree of stability.

In vegetable production it is particularly important that compost is properly composted and stable. Immature and unstable compost will deplete the soil of plant nutrients required for the crop.

Table 4 below shows how AS4454 differentiates between composted (immature) and mature compost products using various technical measures of compost maturity:

- composted product must meet three of the criteria with at least one from Group A (Biological Activity) and one from Group B (Plant Growth)
- mature composts must meet four of the criteria with at least two from Group A (Biological Activity) and two from Group B (Plant Growth).

Only mature compost should be used in horticulture production.

Table 4 Maturity criteria for composts

Parameter		Composted product	Mature compost
Group A - Biological Stability		Pass at least 1 out 3	Pass at least 2 out of 4
Solvita® Maturity Index		≥ 5 or 6	≥ 7 or 8
Nitrogen Drawdown Index (NDI)		>0.2	> 0.5
Specific oxygen uptake rate (mg O_2/g BVS/hr) at 30°C		< 3	≤ 1
Carbon dioxide respiration (mg CO_2/g BVS/day) at 30°C		≤ 12	≤ 8
Dewar self-heating (°C)		≤ 20°C	≤ 10°C
Group B - Plant Growth Tests		Pass at least 1 out of 3	Pass at least 2 out of 4
Ammonium N (mg/kg)		< 200	< 100
Plant growth test (Bioassay)	Root length (mm)	> 60mm	N/A
	In-vitro germination and root elongation (% of control)	> 80%	> 90%
	Seedling emergence & growth (% of control)	Emergence >80%, Vigour >85%	Emergence > 90%, Vigour > 95%
Ammonium to Nitrate ratio		< 3.0	< 0.5
Volatile Fatty Acids (moles/g dry mass)		< 1,000	< 200
NH3 volatile ammonia (gas) (ppm/4-hour test)		< 800 (≥ Solvita® 4)	< 100 (≥ Solvita® 5)

Use

To obtain consistent and optimal benefits, recommendations for use include:

- Incorporate into soil or apply as surface mulch at the beginning of the cropping cycle.
- Obtain a soil test and use as a guide for application rates; e.g. apply at higher rates if SOC/SOM is low;
- Application rates of 10 - 20 wet tonnes/ha annually, or 75-100mm depth for mulches and 50-100 t/ha (approx. 5mm – 10mm depth) for composts.
- Repeated application over several years.

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Disclaimer

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Glossary

Terminology	Definition
AS 4454	Australian Standard 4454-2012: *Composts, soil conditioners and mulches*
EC	Electrical conductivity
NSW EPA	New South Wales Environment Protection Authority
RO	Recycled organics
RRE	Resource recovery exemption
RRO	Resource recovery order

NSW Environment Protection Authority

Email: **info@epa.nsw.gov.au** | Website: **epa.nsw.gov.au**

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