RECYCLED ORGANIC FERTILISER FACT SHEET

GRDC
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Using recycled organics and manures in grain-cropping systems

Understanding the chemical make-up of recycled organics is an essential first step in evaluating the potential soil and crop benefits they may provide.

KEY POINTS

- Recycled organic materials including animal manures can provide alternatives to mineral fertilisers.
- A chemical analysis of recycled organics is essential in determining the potential nutrients available, calculating application rates and identifying potential benefits and risks.
- The addition of organic matter can help improve soil structure and increase soil microbial activity, with overall soil-health benefits in the medium to long-term.
- Ongoing soil tests are important in monitoring and managing the potential build-up of nutrients and other chemicals in the soil over time.

Rising fertiliser prices and a desire to improve soil health have increased grower interest in the use of alternative inputs for grain cropping systems. Recycled organics generated from intensive livestock operations, (for example, cattle feedlots, poultry sheds and piggeries) and from municipal authorities (for example, biosolids, garden organics) contain nutrients and organic matter and moisture that can potentially:

- improve soil physical, chemical and biological characteristics;
- increase crop and pasture productivity;
- reduce reliance on inorganic fertilisers; and
- build more resilient farming systems.

PHOTO: EMMA LEONARD

Organic manures can improve soil structure and provide nutrients, however nutrient loss during storage can be substantial.

Recycled organics vary in quality and consistency. Their agronomic benefits as an alternative to mineral fertilisers and long-term soil conditioner also varies.

Depending on the product, benefits may not be apparent until several years after application. However, research indicates that in the medium to long-term, recycled organics and manures can play a role in improving soil quality and crop productivity.

Availability of manures and organic fertilisers

The feedlot and intensive livestock industries have expanded considerably in the past two decades and there is also greater emphasis on recycling among municipal authorities. These trends have both increased the availability of organic materials for use as fertilisers, as 'wastes' become valued inputs.

The major sources of recycled organics available in Australia, by volume are biosolids (1.6 million tonnes per year), feedlot manure (1.3m t/yr), poultry litter (1.1m t/yr), layer chicken manure (470,000t/yr), piggery solids (324,000t/yr), grape mark (154,000t/yr), mushroom compost (150,000t/yr) and cotton gin trash (120,000t/yr).

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Before applying organic fertilisers

The availability of manure or organic product should not necessarily be the determining factor in its use. Growers first need to consider what they hope to gain from using recycled organics. The likelihood of an agronomic response to ANY fertiliser (organic or inorganic) depends on the inherent soil fertility, target yield and yield potential.

Assess soil nutrient status

The concentration of available soil nutrients depends on soil properties, cropping and fertiliser history and stubble and tillage management. Soil testing is recommended to establish the level of baseline of macronutrients (nitrogen, phosphorus, potassium and sulfur) and micronutrients (for example zinc, copper) in the soil.

Identify the nutrient needs of the crop to be grown

Plant nutrient requirements depend on soil fertility, the crop to be grown and the target yield of the crop. Table 1 illustrates plant nutrient requirements for several broadacre crops on most soil types. The rate of nutrients applied should be equal to or greater than the nutrients removed by the crop over time so that soil fertility can be maintained.

Identify other soil constraints

Low organic matter, hard setting soils, surface sealing, problems with water infiltration and other soil health issues can generally be improved by additions of organic matter; therefore, the recycled organic material may primarily be used as a soil improver and secondly as a source of nutrients.

TABLE 1 Typical yields (t/ha) and rates of nitrogen (N), phosphorus (P) and potassium (K) removed (kg/ha) by selected broadacre crops grown under Australian conditions (adapted from Glendinning 2004)

Crop	Example yield (t/ha)	Nutrient removed per tonne yield (kg/t)			Nutrient removed at example yield (kg/ha)		
		N	P	K	N	P	K
Wheat	4	21	2.6	3.7	84	10	15
Barley	3.5	19	2.9	4.4	67	10	15
Oats	4	17	3	3.9	68	12	16
Canola	2.8	40	6.5	9.2	112	18	26
Cereal hay	9.5	20	2	12	190	19	114
Hay	5	35	2.7	20	175	14	100

TABLE 2 Selected chemical characteristics of different types of recycled organics

Property	Fresh poultry litter	Composted garden organics	De-watered biosolids	Cattle feedlot manure	Piggery solids (deep litter)
pH	5.8-8.1	6.9	6.7	7	7.3
EC1:5 (dS/m)	6.8-16	2.2	0.4	12.4	7.6
Dry matter (%)	64-79	74	17.7	45-80	51
Moisture (%)	21-36	26	82	20-54	49
Carbon (%)	28-36	24	26-36	11-44	65
Density (m^3/t)	2-2.25		6.2-9		
Nitrogen (N) (%dw)	2.6-5	1	3.7	2.2	1.6
Phosphorus (P) (%dw)	1.2-2.6	0.2	3.4	0.8	0.7
Potassium (K) (%dw)	1.0-2.8	0.5	0.3	2.3	1
Cu (mg/kg)	25-160	57	600	40	200
Zn (mg/kg)	239-580	151	600	323	170

Identify the nutrient content and physical properties of recycled organic material to be used.

The quality and nutrient content of recycled organics can vary considerably (Table 2) and is influenced by a number of factors including:

- product type;
- animal type and size;
- housing and rearing management (for example, bedding);
- diet; and
- storage, treatment and further processing such as composting.

Calculate the application rate of organic material required to meet crop requirements

Calculations should be based on dry weight of product and take into account potential nutrient losses as a result of chemical processes, particularly nitrogen, and time required to mineralise nutrients before they become available to plants (see *Testing organic inputs*, next page).

Assess the risks

Manures and recycled organic fertilisers are derived from waste products and may contain contaminants or undesirable elements, which if not considered, may result in adverse outcomes or create a nuisance to neighbours.

The key risks associated with applying recycled organics and manures are: heavy metals; pathogens; odour, dust and air quality; eutrophication; salinity; sodicity; weeds; and phyto-toxicity.

Applying a risk management framework identifies and ranks risks and develops proactive approaches for managing risks.

Nutrient availability

Users of recycled organics should be aware that benefits may not become apparent until several years after application and that cost-effectiveness will be site specific.

TESTING ORGANIC INPUTS

Having individual samples of recycled organics or manures tested or obtaining a 'batch certificate' is essential for determining appropriate application rates and likely nutrient contribution from them.

Make sure sampling procedures include the following principles:

- use clean sampling equipment;
- take at least five sub-samples from a batch of no more than 100 tonnes;
- have the same number of sub-samples in each batch; and
- mix batch sub-samples thoroughly to make a composite sample for analysis. A composite sample allows the characteristics of a batch to be more accurately estimated.

In lieu of specific standards for manures and other types of recycled organics, samples can be tested using the procedures defined in the Australian Standards for composts, mulches and soil conditioners (AS4454) (Standards Australia, 2003). Commercial soil testing laboratories should at least be able to provide a comprehensive nutrient analysis for recycled organics.

What is the likely nutrient contribution from manures or organic wastes?

Organic materials can be applied primarily for their nitrogen (N), phosphorus (P), or potassium (K), depending on crop requirements and quantities available. With any organic product it takes time for nutrients to become available, as microbial action is required to convert them into a form plants can use. Microbial activity is greatest in warm soils with good levels of available moisture.

Table 2 provides an example of how to calculate the typical nutrient contribution (kg/ha) from manures or organic wastes.

Use dry matter/dry weight as the basis for calculating nutrient loads in specific recycled organic.

Example: Applying fresh manure at 15m^3/ha

Chemical analysis of manure to be applied:

Carbon (C)	30 (%dw)
Nitrogen (N)	2.5 (%dw)
Phosphorus (P)	1.8 (%dw)
Potassium (K)	1.5 (%dw)
Moisture	30%
Density	440kg/m^3

Application rate as fresh manure =
density (kg/m^3) x application rate (m^3/ha)
i.e. 440kg/m^3 x 15m^3/ha = 6600kg/ha

Application based on dry weight =
wet application rate (kg/ha) - moisture content (%)
i.e. 6600kg/m^3 – 30% moisture = 4620 kg/ha

Nutrients applied, based on dry weight and chemical analysis (above)

Carbon	30% of 4620kg = 1386kg/ha
Nitrogen	2.5% of 4620kg = 116kg/ha
Phosphorus	1.8% of 4620kg = 83kg/ha
Potassium	1.5% of 4620kg = 69kg/ha

Nitrogen (N)

- Nitrogen in fresh manures is relatively volatile; as much as 50 per cent may be lost as ammonia (NH_3) or nitrogen (N_2) gases during storage and after it is applied to land. From the example above, effective nitrogen may be only 50 per cent of 116kg/ha, or 58kg/ha.
- Exposure to high temperatures and water prior to application, and after application especially if recycled organics are broadcast on the soil surface, will increase the rate of nitrogen loss.
- The remaining organic nitrogen needs to be converted to an inorganic form (that is, mineralised) before it can used by plants.
- Depending on application technique, soil and weather conditions only 30 to 70 per cent of the remaining nitrogen in the applied fertiliser may be available to plants in the first year after application. (From the example, 30 to 70 per cent of 58kg/ha).
- Where farming systems allow, incorporating manure into the top 10cm of soil several months before seeding will reduce nitrogen losses via volatilisation.
- Allowing several weeks between applications of fresh manure and planting will help prevent ammonia toxicity that may damage developing seedlings, particularly where manure is broadcast on the soil surface.

PHOTOS: EMMA LEONARD

(Left) Sample across and to depth in heaps, take at least five sub-samples per 100 tonnes and mix to create a composite sample for testing.
(Right) Not all nutrients applied in organic materials are immediately available; for example only 20 per cent of phosphorus may be available in the year of application.

Phosphorus (P)

The phosphorus contribution of recycled organics is more stable, although it is still difficult to predict how much will be available to plants over time.

- Phosphorus is an immobile nutrient and incorporating it into the soil will improve contact with the soil and plant roots as well as reduce the potential for loss via run-off.
- Phosphorus also needs to be mineralised before it becomes available to plants.
- In the first year of application only 10 to 50 per cent (assume 20 per cent) of the total phosphorus applied in organics is likely to be available to the crop. (Based on the example, 20 per cent of 83kg/ha = 17kg/ha).
- Repeated application of recycled organics based on their nitrogen content, can lead to the accumulation of phosphorus in the soil, which can have adverse impacts on water quality.
- It may be more appropriate to base application rates of recycled organics on phosphorus rather than nitrogen and use mineral or plant-fixed nitrogen as a supplement to meet crop requirements.

Potassium (K)

- Potassium is also an immobile nutrient and incorporating recycled organics into the soil will improve its availability and prevent run-off.
- Potassium can also build-up in the soil, resulting in increased soil sodicity, and potentially resulting in contaminated run-off, particularly where material has been broadcast on the soil surface.

Sulfur, zinc, and copper

- The micronutrients zinc and copper or macronutrients such as sulfur are also found in recycled organics, particularly chicken manure and biosolids.
- Recycled organics offer an opportunity to supply these nutrients, which would otherwise be applied as supplements in conjunction with mineral fertilisers.
- The accumulation of these nutrients that are generally required in small amounts is a risk that must be managed through application rates.

A cost-effective fertiliser?

The short-term value of recycled organics as an alternative to inorganic fertilisers can be assessed by assigning an economic value per kilogram of nutrient for inorganic fertilisers (Table 3). This can then be used as the basis for comparing the potential value of nutrients in recycled organics (Table 4).

- Additional costs include transport, handling, storage and spreading costs, which will vary from site to site and product to product.
- Application issues will be an important consideration in deciding whether or not to use recycled organics. Fresh manures, for example, can be lumpy and difficult to apply evenly. Aged and screened products will be easier to apply but may be more expensive.
- The volatility of nutrients in recycled organics makes it difficult to accurately determine the effective quantities of plant-available nutrients, which can also make it difficult to determine the economic value of nutrients in a fertiliser.

What are the other benefits?

The other effects of using recycled organics are also variable, depending on the product used and how it is applied. Soil biology is complex and relatively little is understood of the effects of amendments on soil biological processes and benefits may not become apparent until several years after application. The cost-effectiveness will be site specific, however, potential benefits include:

- the addition of organic matter and carbon to soils;
- improved soil structure, infiltration, water-holding capacity and porosity;
- improved soil biological properties, including microbial biomass and activity, as well as macro-fauna; and
- improved yields as a result of improved soil structure.

TABLE 3 Nutrient value per kilogram in common mineral fertilisers (recommended retail prices vary between suppliers and over time, and exclude transport cost)

Nutrient	Average	RRP ($/t)	Nutrient concentration (%)	Nutrient value ($/kg)
Nitrogen (N)	Granular urea	600	46	1.30
Phosphorus (P)	Single superphosphate	375	9	4.17
Potassium (K)	Muriate of potash	817	50	1.63

TABLE 4 Nutrient value per kilogram in an example recycled organic material, based on prices for common mineral fertilisers in Table 3.

Nutrient	Nutrient concentration (%dw)	Nutrient mass (kg/dwt)	Nutrient value ($/kg)	Nutrient value ($/t)	Nutrient value ($/m^3)*
Nitrogen (N)	2.6	26	1.30	34	15
Phosphorus (P)	1.8	18	4.17	75	33
Potassium (K)	1	10	1.63	16	7
Total				125	55

*Assumes a density of 2.26m^3/t

Managing risks

There are a number of potential risks involved in using recycled organics, which relate to agronomy, environmental pollution, public health and safety.

Soil contamination

While recycled organics may improve soil health the potential build-up of some nutrients and heavy metals and other chemicals in the soil is an issue that needs to be considered and managed.

- Chemical analysis of the product being used provides essential information to calculate the rates of heavy metals, nutrients, sodium and other potentially toxic elements being applied over time.
- Using phosphorus rather than nitrogen as the basis for application reduces the risk of building up phosphorus to detrimental levels.
- Soil testing is essential to monitor changes in soil and adjust application rates accordingly.
- Management practices should be modified where increases in salinity and sodicity are observed.

Heavy metals

- Limit the application of recycled organics to ensure maximum in-soil limits of heavy metals, as defined by relevant state guidelines, are not exceeded. Further information on state guidelines and regulations is generally available from the Environment Protection Authority or equivalent agency in each state.
- Avoid using products high in metals on soils with high background metal concentrations.

Nutrients

- Use nutrient budgeting to determine loading of nutrients, particularly nitrogen and phosphorus and limit rates to ensure they do not accumulate in the soil over time.
- Maintain vegetated filter strips in riparian areas.
- Do not store or apply manures within prescribed distances to sensitive areas (for example, surface waters, bores) as prescribed by state Environmental Protection Agencies.

Salinity and sodicity

- Limit application rates of recycled organics to < 50-100 dwt/ha/yr.
- Use mass balances (application rates and crop use based on yields, over time) to determine loading of

Na and K and limit rates to ensure they do not accumulate in the soil over time.

- Use soil testing to monitor changes in exchangeable sodium percentages (ESP) and Electrical Conductivity over time.

Phyto-toxicity

- Use chemical analysis to identify potentially toxic elements.
- Use composted products or allowing sufficient time between application and planting will minimise the potential for phyto-toxicity, such as ammonia toxicity.

Human and animal health

Recycled organics are the products of waste streams and may contain pathogens which could present a disease risk to people and animals. There are a number of steps that can be taken to reduce potential risks.

- Consider using pasteurised products, such as compost and heat-treated pellets.
- Establish withholding periods for both people and stock in paddocks where recycled organics have been broadcast on the soil surface.
- Exclude stock from paddocks where recycled organics are being stored.
- Incorporate recycled organics into the soil.
- Provide protective equipment and appropriate vaccinations for workers who are likely to come into contact with raw products.

Odour, dust and air quality

Talking with neighbours and local authorities is important in managing potential odour and air quality issues and will allow you to develop a management strategy to prevent problems, and to respond to any issues that do arise.

- Where possible locate storage facilities away from public view and neighbours.
- Maintain trees and shrubs on property boundaries.
- Advise neighbours about planned spreading times and dates.
- Consider the prevailing wind direction and intensity when planning spreading operations.
- If odour management is an ongoing problem, even after these strategies have been implemented, consider using stabilised products such as mature composts or pellets.

Weeds

- When using raw manures ensure it comes from a trusted source.
- Ensure all material is exposed to temperatures greater than 55°C for three consecutive days.
- Spray weeds with herbicides or remove mechanically, where necessary.

A slurry of poultry manure being slotted into the subsoil behind a deep ripping tine. Such treatments have resulted in greater root growth and increased biological activity in the subsoil.

PHOTO: BRAD COLLIS

Useful resources:

Centre for Recycled Organics in Agriculture, NSW Industry and Investment	**www.dpi.nsw.gov.au/research/centres/croa**	
State Environmental Protection Agencies and Authorities	**SA**	**www.epa.sa.gov.au**
	WA	**www.epa.wa.gov.au**
	NSW	**www.epa.nsw.gov.au**
	VIC	**www.epa.vic.gov.au**
	QLD	**www.derm.qld.gov.au**
	TAS	**www.epa.tas.gov.au**

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