Meat Chicken Technical Environmental Note 4

Land Application of Spent Litter

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Introduction

Land application to crops and pasture is the most widely adopted and cost effective way of utilising the nutrients in spent litter. It also reduces the need for commercial fertilisers and lowers the cost of crop production. One of the advantages of applying organic fertilisers, such as spent litter from meat chicken production, is that not all of the nutrients are available to the plant immediately. It acts as a slow release fertiliser, thus giving the plant a better chance to access nutrients when they are required.

However, spent litter, like other organic manures, is not a balanced fertiliser. Hence, some nutrients need to be added via inorganic fertilisers to meet crop requirements. The application of spent litter also needs to be carefully managed, since inappropriate and over application can result in nutrients leaching through the soil profile or being exported off-site in runoff.

In calculating a sustainable utilisation area for spent litter, the application of any element (particularly nitrogen and phosphorus) should not exceed the addition of the following:

- The rate at which an element can be taken up by the plant and removed from the site.
- The amount that can be safely stored in the soil (primarily phosphorus, although soil storage of the phosphorus in spread manures is not permitted in some states (Victoria and South Australia)).
- The amount released to the atmosphere in an acceptable form (primarily the gaseous loss of nitrogen via ammonia volatilisation).

When planning an appropriate application area, the amounts of all elements (nitrogen, phosphorus, salts and heavy metals) need to be considered individually. As previously mentioned, spent litter will not generally be a balanced fertiliser, thus the safe application rate will be determined by the most limiting element.

When spreading spent litter, the aim should be to make the maximum use of the fertiliser value of the product and at the same time avoid any potential deleterious effects, such as soil degradation and contamination of ground and surface water.

Soils

The best soils for the application of spent litter are deep, well-structured and well-drained clay loams. These are more suitable than both highly permeable sands and impermeable heavy clays. Shallow soils with significant amounts of rock and gravel or soils with a high salt content should also be avoided. Soils with high clay contents are better able to store nutrients, while sandy soils are more susceptible to nutrient leaching.

A number of soil degradation issues should be considered when spreading spent litter, including erosion, salinity, sodicity, soil structure decline and chemical contamination.

Soil Phosphorus Sorption Capacity

Soils vary in their ability to store phosphorus. In general, sandy soils have a poor phosphorus sorption capacity, while strongly weathered clay soils such as krasnozems have a high storage capacity. The amount of phosphorus that a soil can safely store is known as the safe phosphorus storage capacity. Because of the low nitrogen to phosphorus ratio of spent litter (typically 2:1), compared to the high nitrogen to phosphorus ratio of most crops (typically 5:1), phosphorus will generally be the most limiting nutrient when applying spent litter if no allowance is made for phosphorus storage capacity. Consideration of the safe phosphorus storage capacity may significantly increase the allowable spreading rate. However, the allowance for phosphorus storage capacity on by-product utilisation areas varies from state to state and local codes of practice and guidelines will need to checked. In some states, the phosphorus application rate is restricted to the phosphorus uptake by the plants. Table 1 shows the safe P storage capacity of different soils (kg/ha) based on one metre of soil depth.

TABLE 1. SAFE PHOSPHORUS STORAGE CAPACITY OF DIFFERENT SOILS (KG/HA).

Australian Soil Classification	Great Soil Group	Soil Bulk Density (kg/m^3)	P Sorption Capacity (mg P/kg soil)	Safe P Storage Capacity (kg/ha)
Brown Sodosol	Soloths	1,300	50	650
Stratic Rudosol	Podzol	1,500	45	680
Grey Vertosol	Grey Clay	1,200	73	880
Black Vertosol	Black Earth	1,300	73	950
Brown Dermosol	Prairie Soil	1,200	102	1220
Brown Kandosol	Yellow Earth	1,300	142	1850
Brown Chromosol	Yellow Podzolic	1,200	194	2330
Red Ferrosol	Krasnozem	1,300	280	3640
Red Chromosol	Red Podzolic	1,200	304	3650

Crop Production

The quantity of nutrients exported in a harvested crop depends on the nutrient content of the crop and the crop yield. The most efficient way to remove nutrients is to grow a crop that is removed from the paddock; grazing only has a low nutrient removal rate.

Since the meat chicken industry in Australia is mostly located close to urban centres, a large proportion of spent litter is utilised on horticultural crops. These crops are generally very intensive, with high yields and corresponding nutrient removal rates can be quite high. Table 2 shows the typical nutrient content of various broadacre and horticultural crops and normal dry matter yields.

TABLE 2 NUTRIENT CONTENT (DRY BASIS) AND TYPICAL YIELD RANGE FOR VARIOUS CROPS.

Crop	Dry Matter Nutrient Content (%)			Normal Yield Range
	N	P	K	Dry Matter (t/ha/yr)
Dry Land Pasture (cut)	3.0	0.3	1.5	1 to 4 t/ha/yr
Irrigated Pasture (cut)	3.0	0.3	1.5	8 to 20 t/ha/yr
Lucerne Hay (cut)	3.1	0.3	2.5	5 to 15 t/ha/yr
Maize Silage	3.0	0.5	2.0	10 to 25 t/ha/yr
Forage Sorghum	2.2	0.3	2.4	10 to 20 t/ha/yr
Winter Cereal Hay	2.0	0.3	1.6	10 to 20 t/ha/yr
Seed Barley	1.9	0.3	0.4	2 to 4 t/ha/yr
Seed Wheat	1.9	0.4	0.5	2 to 4 t/ha/yr
Rice	2.0	1.7	1.3	4 to 8 t/ha/yr
Seed Oats	1.5	0.3	0.4	1 to 4 kg/ha/yr
Grain Sorghum	2.0	0.3	0.3	2 to 8 t/ha/yr
Grain Maize	2.0	0.3	0.4	2 to 8 t/ha/yr
Chickpea	4.0	0.4	0.4	0.5 to 2 t/ha/yr
Cowpea	3.0	0.4	2.0	0.5 to 2 t/ha/yr
Faba Bean	4.0	0.4	1.2	0.5 to 2 t/ha/yr
Lupins	4.5	0.3	0.8	0.5 to 2 t/ha/yr
Navy Bean	4.0	0.6	1.2	0.5 to 2 t/ha/yr
Pigeon Peas	2.6	0.3	0.9	0.5 to 2 t/ha/yr
Cotton	2.0	0.4	0.8	2 to 5 t/ha/yr
Asparagus	0.4	0.4	2.5	0.5 to 2 t/ha/yr
Beans	3.1	0.3	2.6	4 to 8 t/ha/yr
Beetroot	4.2	0.3	4.0	5 to 15 t/ha/yr
Broccoli	3.9	0.5	3.0	5 to 15 t/ha/yr
Cabbage	3.5	0.4	4.0	5 to 15 t/ha/yr
Carrot	0.9	0.4	1.7	5 to 15 t/ha/yr
Cauliflower	3.6	0.5	4.3	5 to 15 t/ha/yr
Celery	2.1	0.3	4.0	5 to 15 t/ha/yr
Lettuce	4.0	0.5	6.0	5 to 15 t/ha/yr
Onion	1.3	0.4	2.2	5 to 15 t/ha/yr
Peas	2.0	0.2	1.2	4 to 8 t/ha/yr
Potato	2.5	0.2	2.2	5 to 15 t/ha/yr
Tomato	3.6	0.7	4.7	5 to 15 t/ha/yr

Calculating Area Requirements

Listed below are examples of area requirements for different production systems. Spent litter nutrient availability is based on 500,000 birds turnoff/yr (5 batches/yr of 100,000 birds). The initial clean bedding is assumed to be wood shavings. If chopped straw was used as the clean bedding material, more area would generally be required due to the higher nutrient content of this bedding material.

TABLE 3 LAND REQUIREMENTS FOR SUSTAINABLE APPLICATION OF SPENT LITTER FROM A 500,000 BIRD/YR OPERATION*.

Crop Type 1 & Yield (t/ha)	Crop Type 2 & Yield (t/ha)	Area for N Uptake (ha)	Area for P Uptake (ha)	Area for P Storage of 20 yrs** (ha)	Area for K Uptake (ha)
Irrigated pasture (10)	Irrigated pasture (10)	40	231	91	39
Grain sorghum (5)	Seed barley (3)	151	572	119	459
Maize silage (20)	Cereal hay (15)	26	97	59	18
Lucerne hay (12)	-	64	386	108	39
Potato (10)	Cereal hay (10)	53	262	96	31
Carrot (10)	Cauliflower (10)	53	154	76	19
Beans (6)	Broccoli (10)	41	204	87	26

* Assumes 100% uptake efficiency of nutrients.

** 20 year storage assumes the application area is used for 20 years.
i.e P storage per year = total P storage capacity/20

Nutrient Availability

Most nutrient uptake by plants occurs when the nutrients are in inorganic forms. Not all the nutrients applied in spent litter for a crop are available to the plant in that year. Some elements must be converted from the organic to the inorganic form by microorganism decomposition.

The availability of nitrogen in the first year of application will vary greatly between 30% and 80% depending on the spreading method and the environmental conditions. Nitrogen in spent litter is present in both the organic and inorganic forms. Generally, about one-third of the nitrogen in the spent litter is in the ammonium form, the rest is in the organic form. Organic nitrogen needs to be converted via mineralisation to the inorganic form to be available to a plant. During this process, nitrogen may be lost to the atmosphere by ammonia volatilisation and denitrification. After the first year of application about 25 – 50% of the organic nitrogen is converted. All of the inorganic nitrogen (ammonium nitrogen and nitrate nitrogen) is readily available to the plant. However, nitrogen in these forms is also highly mobile and can be readily leached through the soil profile. If spent litter is left on the soil surface and not incorporated, a significant amount of the ammonium nitrogen will be lost to the atmosphere as ammonia gas. Ammonium nitrogen incorporated into the soil is nitrified to nitrate and is then readily available to the plant. With excess water, nitrate can be readily lost through leaching and denitrification.

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