ENVIRO FACT SHEET

Setting Application Rates for Layer Manure

Poultry layer manure (caged layer manure and barn litter) can be a valuable nutrient resource for pasture and crop production systems. However, it must be managed carefully to realise the most value and to prevent losses of nutrients to the environment where they can cause harm.

Nutrient budgeting is a way to account for nutrient movements at the paddock scale to maximise the efficiency of use. It is a tool to help to keep farming operations sustainable. By understanding the nutrient demands of a crop or pasture, an appropriate manure rate can be determined. This saves money and can improve long term performance. Nutrient budgeting can also reduce the risk of losing nutrients to the atmosphere, surface water and groundwater by matching application rates with plant demand.

Nutrient budgets firstly require the calculation of the total inputs of nutrients for the year, including estimates of nutrients added by manure or fertiliser. Secondly, the mass of nutrients likely to be used by the crop or pasture is determined. Nutrients that are not taken up by the crop are either held in the soil or removed from the system through leaching or gaseous losses.

Setting up a nutrient budget

Nutrient budgets require knowledge of:

- Nutrient levels in the soil
- Nutrient requirements (i.e. outputs – removal through plant harvest, export of livestock and losses to the environment).
- Nutrient inputs (i.e. manure, fertiliser)
- Maximum recommended soil nutrient levels

These items can be calculated on a per hectare basis for any area where the same basic management is occurring. A nutrient budget can be calculated using information from previous years to help make predictions for the coming season. The first step is to assess the level of nutrients in the soil.

What nutrients are in the soil?

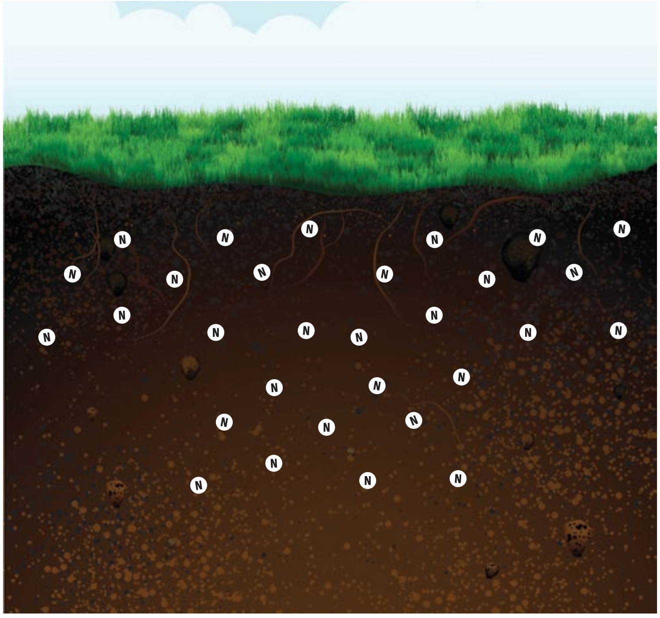
The nutrient status of the soil can be discovered by soil testing, and this is particularly important in paddocks with a history of fertiliser or manure application. Refer to the *Egg Industry Environmental Guidelines* (Edition II, McGahan et al., 2018) for information on soil sampling and testing recommendations.

Once a soil analysis has been done, there are two approaches to assessing soil nutrient levels: i) calculating the total quantity of nutrient per hectare of land, or ii) using 'standard' nutrient targets for different crops or pastures. Calculating nutrient quantities may require agronomic advice. However, standard nutrient targets are available from reference books for most crops and regions. It is important to realise that standard nutrient target levels are influenced by the specific soil properties on your farm such as the ability of the soil to bind phosphorus (P sorption). Some example phosphorus (P) levels for soils in manure use areas are given in *Table 1*. It shows low medium and high soil P levels relative to crop P demand. Examples of low, moderate and high crop P demand are pastures, grain crops, and vegetables respectively.

Table 1. Soil P levels relative to crop demand and sorption

Soil P status	Soil P sorption	Crop P demand		
		Low	Moderate	High
Low	Low	< 10	< 15	< 20
	Moderate to high	< 20	< 30	< 50
Medium	Low	10-30	15-45	20-60
	Moderate to high	20-60	30-90	50-150
High	Low	> 30	> 45	> 60
	Moderate to high	> 60	> 90	> 150

Adapted from Moody and Bolland 1999



Soil nitrogen levels are generally measured as nitrate (N). Ideal soil nitrate-N levels will depend on season, crop and soil interactions and are best determined by an agronomist. However, rough estimates can be made using standard target levels from a reference book such as *Interpreting Soil Test Results* (Hazelton and Murphy, 2007) from CSIRO. Nitrate is highly mobile and easily lost from the soil, reducing plant availability and potentially causing impacts to groundwater. Recommended soil Nitrate-N concentrations at the bottom of the root zone are shown in *Table 2*.

Table 2. Recommended maximum nitrate concentrations

Soil Texture	Moisture Content*	Nitrate concentration**
Sand	0.12	1.2
Sandy-loam	0.15	1.5
Loam	0.17	1.7
Clay-loam	0.20	2.0
Light Clay	0.25	2.5
Medium Clay	0.35	3.5
Self-Mulching Clay	0.45	4.5

Adapted from Skerman 2000
* Soil gravimetric moisture content at field capacity (g water/g soil)
** Limiting soil nitrate-nitrogen concentration (mg NO3N/kg soil)

Measuring total nitrogen can also be helpful on paddocks that have received manure, because this will give an idea of the total reserves of nitrogen that can mineralise from the soil, providing nitrogen for crop or pasture growth.

Outputs

Nutrient outputs can be used to estimate required annual fertiliser or manure application rates.

Once the major system inputs have been determined, similar calculations are needed for the main outputs. Main outputs may include hay, grain or livestock products (liveweight, milk or wool). For livestock, the nutrient content of live beef is approximately 2.4kg N, 0.7kg P and 0.18kg K / 100kg live weight. For milk production, 1000L of milk will remove about 5kg N, 1kg of P and 1.5kg of K. Grazing properties export relatively small amounts of nutrients in the livestock. For example, selling 100 beef steers weighing 500 kg/head in liveweight gain, exports about 1,200kg N, 350kg P and 90kg K per year. Crops generally remove much larger amounts of nutrient per hectare than livestock as shown in *Table 3*.

Table 3. Yield and nutrient off-take with some crops

Crop	Yield (t/ha)	N (kg/ha/yr)	P (kg/ha/yr)
Dryland pasture hay	1-4	20–80	3–12
Irrigated pasture hay	8-20	160–400	24–60
Lucerne hay	5-15	150–450	15–45
Dry land winter cereal (grain only)	2-4	40–80	6–20
Dry land winter cereal (grain + straw)	2-4 grain (+2-5 t straw)	59–239	9–20
Grain sorghum	2-8	40–160	6–24
Forage sorghum	10-20	200–400	30–60

Adapted from Reuter and Robinson 1997

Inputs – fertiliser and manure

Once nutrient availability in the soil, and the nutrient requirement of the crop are known, the required fertiliser or manure inputs can be calculated.

Fertiliser nutrient inputs are calculated by multiplying the application rate (kg/ha) by the nutrient content to give a mass of nutrient applied per hectare. For example, the amount of phosphorus applied with single superphosphate (9% P) applied at 125kg/ha to grazing land is calculated as follows:

125 x 0.09 = 11kg/ha of P.

The standard analysis for fertiliser is printed on the bag or is readily available from the manufacturer.

For manure inputs, a similar calculation is needed to estimate the amount of nutrient per tonne of manure 'as spread', but the key difference is that moisture content must be taken into account. The first step is to obtain an analysis for the manure from a laboratory or to use standard analysis data (refer to the fact sheet; "Composition of Layer Manure.").

Manure analysis results are generally provided on a 'dry basis (db)', however all manure contains moisture at the time of spreading. This moisture acts to dilute the nutrient concentration in each tonne of manure. To calculate the amount of phosphorus in a tonne of layer manure with a dry matter content of 70% (or a moisture content of 30%) and a total phosphorus content of 2.3%, use the following process:

1,000 kg x 0.7 (70% dry matter)

= 700 kg dry matter.

700 kg x 2.3% db (average phosphorus content in layer manure)

= 16.1 kg P/tonne.

This same process can be applied to other nutrients in layer manure.

Nutrient availability

When using manure, not all of the nutrient contained is immediately available to the plant an this must be taken into account when setting application rates. Plant nutrient uptake occurs when nutrients are present in an inorganic form. Some nutrients need to be converted from the organic to the inorganic form by microorganism decomposition before they become available for plant uptake. Of the macro nutrients available in layer manure, nitrogen and phosphorus can vary widely in nutrient availability, while potassium is stable and highly available from the time of application.

Generally, about 10–25% of the nitrogen in fresh layer manure is present in the ammonium form, while the remainder is in a slower release, organic form. This nitrogen rapidly becomes available to the plant after application, but it is also easily lost to the atmosphere. Losses are highest where manure is applied to the surface and allowed to dry out.

The remaining nitrogen is contained in an organic form and will mineralise over time, releasing nitrogen for plant growth. Between 30–80% of the total nitrogen is likely to become available in the first year. However, the mineralisation rate depends upon a number of factors including soil health, temperature and moisture. See the fact sheet in this series called 'Spreading Layer Manure', for more information.

Immediately available phosphorus may be around 20% in layer manure, and up to 60% may be available in the first year. The availability of phosphorus depends on soil characteristics such as (buffering capacity) and the mineralisation and demineralisation of P by soil microbes. Phosphorus will be more easily accessed by plants where manure is incorporated, but this is not essential.

The nutrient balance

Once soil nutrient levels, outputs and inputs have been calculated, the overall nutrient budget is:

Final soil nutrients = initial soil nutrients + inputs - outputs.

The result will show if more or less nutrient inputs are required to balance the equation. Where the final soil nutrient level is higher than the initial level, nutrients will be stored in the soil or lost to the environment. Losses should be avoided wherever possible, as these are both a financial cost and a risk to the environment. In particular, nitrogen and phosphorus are harmful to water and in some cases air quality, and need to be minimised by balancing the nutrient budget as much as possible without compromising yields. Nutrient budgets are a useful tool for managing fertiliser and manure applications, providing greater efficiency within the system, saving money and helping to protect the environment, giving a win-win situation.

References and Further Reading

Moody, P. and M. Bolland, *Phosphorus, in Soil analysis: An interpretation manual* K. Peverill, L. Sparrow, and D. Reuter, Editors. 1999, CSIRO Publishing: Melbourne, Australia. p. 187-220.

Hazelton, P. and Murphy, B. (2007) *Interpreting soil test results: What do all the numbers mean?* Collingwood, Victoria: CSIRO Publishing.

Skerman, A., *Reference Manual for the Establishment and Operation of Beef Cattle Feedlots in Queensland*, in Information Series QI99070. 2000, Queensland Cattle Feedlot Advisory Committee, Department of Primary Industries and Fisheries: Queensland.

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