Dairy farm nutrient management planning: Why is it important and what should be included?

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Abstract
Nutrient management has significant implications for dairy farm productivity, nutrient use efficiency (NUE) and nutrient losses to the environment. Unfortunately, the quality and consistency of nutrient advice provided to dairy farmers varies. Dairy Australia and Fertcare® have recently supported the development of a national standard for nutrient management planning (Dairy NMP). This approach was developed by leading government and industry experts utilising the best available scientific knowledge. The new Dairy NMP aims to optimize the return from on-farm and commercial nutrient resources in a manner that minimize nutrient losses. The Dairy NMP standard will help lift the quality and consistency of nutrient advice to dairy farmers. This will assist dairy farmers by improving nutrient management decisions for better productivity and environmental outcomes.

Keywords
Dairy nutrient use efficiency, fertiliser, manure, productivity, GHG emissions, water quality.

Introduction
The global livestock sector is a major contributor to greenhouse gas, phosphorus (P) and nitrogen (N) emissions. Consequently, global markets are now expecting evidence of reduced environmental harm and industry and government policy responses to deal with excess nutrients are universally based on a sound scientific understanding of nutrient requirements and a farm-based nutrient management planning approach. There is growing recognition that to achieve the goals of improving nutrient use efficiency and reducing environmental emissions, nutrient management planning approaches need to be consistent, comparable, complete, accurate and transparent.

Dairy farm nutrient management equates to directly or indirectly providing nutrients to soil, to support plant growth, which then is utilized as feed by dairy cows, or by importing feed nutrients directly. The challenge for plant and animal nutrition in dairy systems world-wide is managing the high fluxes of nutrients imported and flowing through production systems, challenged by inherent inefficiencies, recycling requirements and leakages within the production system.

Ongoing intensification of dairy systems in Australia has led to substantial changes in the dairy industry. From 1990 to 2020, there has been a reduction in the number of farms (70% decrease), increase on overall farm size (from 160 ha to 270 ha), increases in the average herd size per farm (from 113 to greater than 300 cows) and milk production has doubled (Dairy Australia 2020). Another important change has been the increasing reliance on imported feed and a dramatic increase in the amount of nitrogen fertilizer applied.

Australian dairy production systems continue to be diverse and range from pasture only to fully housed and total mixed ration operations. Most Australian dairy farms utilize pasture, supplemented with high grain feeding, but higher milk production is generated from more intensive systems. These farms produce a large proportion of national milk, have larger herds, greater imported feed inputs in confined feeding areas, and therefore, more manure for collection, storage, and land application. However regardless of the system, an industry adopted Dairy NMP will ensure a consistent approach to nutrient management across Australia.

Key components of the Dairy NMP

The key information sources required to develop a NMP are provided in Table 1 (Fertilizer Australia 2020). All components of a Dairy NMP are basic farm and nutrient management practices, with required information readily available from a successful dairy farm business.

The determination of nutrient budgets and nutrient use efficiency is now globally recognized as a starting point for nutrient management planning. A nutrient budget accounts for the sum of the nutrient imports, minus the sum of the nutrient exports (Rugoho et al. 2017). In most dairy systems the largest nutrient imports are bought in feed and fertilizer, while the largest export is almost always in milk. An estimate of NUE is provided by what proportion of the total imported nutrients end up in total exported product.

Assessments of nutrient budgets across diverse dairy farms nationally, has demonstrated a wide range in nutrient use efficiencies and some large nutrient surpluses (Gourley et al. 2012; Rugoho et al. 2017). In general, nutrient use efficiencies on most Australian farms are likely to be below international target levels (Stott and Gourley 2016), as most nations have been down this road for many decades, have higher regulatory requirements including rewards and penalties, and currently have well established tools to simplify and standardize these assessments (McDowell et al. 2017; Gourley and Weaver 2012). For example, in New Zealand it is mandatory for every dairy farm to have a nutrient budget assessment every 2 years, with nutrient balance, NUE and estimated nutrient leaching losses and GHG emissions also provided. With the linking of electronic farm business records, these types of calculations can become autonomous, as is the case in many parts of Europe. Australian nutrient budgeting tools and calculators are much more basic and often not consistent. The use of standardised and published approaches such as the Ellinbank nutrient budget calculator (Rugoho *et al.* 2017) is strongly encouraged, but more work needs to be done to make these tools more contemporary in a web-based environment.

Table 1. Dairy farm nutrient management plan structure and key sources of information.

Dairy NMP components	Key sources of information
• Farm area defined; paddocks grouped into management zones. • Regulatory requirements and environmentally sensitive areas identified. • Whole-farm nutrient balances and nutrient use efficiencies determined.	• Farm map/plan: paddock use, soils, slopes, waterbodies, etc. • Fertiliser / manure / effluent spreading restrictions. • Milk production, types/amounts of feed, fertilizer, animals, manures, etc. pasture/crop legume % estimate.
• Soil sampling areas and sampling routes identified. • Soil analysis and interpretation according to Australian calibrations. • On-farm manure nutrient sources quantified and use optimized. • Pasture and crop composition, growth performance, basic soil health indicators considered. • Manure and fertilizer application strategy incorporating the 4Rs. • Environmental risks identified, documented, and minimized. • Adequate records are created and retained.	• Management zone specific sampling identified. • Management zone specific soil test reports & nutrient recommendations. • On-farm nutrient resource inventory: Solid / liquid manure, organic wastes.

The recognition of heterogeneous nutrient distribution and accumulation patterns within a farm landscape (Figure 1) is also an important part of a dairy NMP. This is most often related to the areas where dairy cattle spend most time and disproportionate deposition of dung and urine, for example night paddocks, sacrifice paddocks, high density feeding paddocks (Aarons and Gourley 2015). Paddocks which receive regular effluent irrigation often are highlighted with excess nutrient accumulation (Gourley at al. 2015). Not only is it poor economics to spread fertiliser on these over supplied areas, but they may also pose an environmental risk through nutrient leaching and surface nutrient runoff (Gourley et al. 2019). In contrast, areas routinely harvested for silage or hay can have high nutrient removal, mining nutrient levels and potentially limiting optimum production.

To determine soil fertility status of different management areas, a comprehensive soil sampling strategy is required. Time and time again, this approach has been proven to save unnecessary fertilizer dollars and enable targeting of fertilizer and manure nutrients in the right place. The Fertilizer Australia guidelines for soil sampling (Fertilizer Australia 2019) provide nationally approved best sampling practice.

Dairy Australia have recently released national nitrogen management guidelines (Dairy Australia 2020) with the aim of improving nitrogen use efficiency and reducing avoidable environmental N losses. Best practice should also include determining the economic optimum N fertiliser rate (Gourley et al. 2017). Based on a database of national N fertilizer response experiments, an online tool is available to assess the most profitable N fertilizer rate for an individual paddock and management system (Stott et al. 2018).

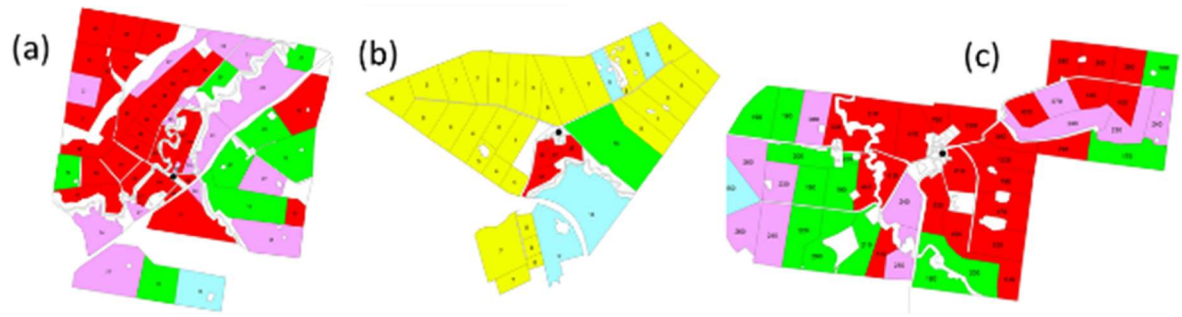

Figure 1. Nutrient distribution maps of three Australian dairy farms: Olsen P levels on conventional farm (a), organic farm (b), Colwell K on conventional farm (c). Nutrient availability: red very high, purple high, green adequate, light blue marginal, yellow deficient. Dot represents the location of dairy shed. Source: Gourley et al (2012).

Dairy cows inefficiently utilise the nutrients they consume, with around 20% of N and P, and less than 10% of potassium and sulphur ending up in milk (Aarons et al. 2019). Collecting, storing and land applying manure is a part of day-to-day dairy farm management and critical to nutrient management planning. Manure nutrient management will require greater emphasis when dairy systems are more intensive, with a large proportion of feed imported and animals in confined feeding infrastructure. A manure inventory enables an estimate of the total manure nutrients currently available for land application. These sources are likely to include liquid manure forms in settling ponds, but also solid stockpiles, and perhaps partially processed and separated materials. The nutrient requirements of pastures and crops on a dairy farm may be totally, partially or only marginally met by the generated and stored manure (USDA 2021).

A dairy NMP should also consider several factors when assessing environmental risk. These include pasture and crop demand for nutrients, probability of rainfall events and intensity, and site-specific characteristics, such as existing soil test values, soil P buffering, slope, erosion potential and proximity to waterways.

Conclusion

The Fertcare® Dairy NMP standard sets the benchmark for what should be expected in a dairy farm nutrient management plan from a professional advisor. The standard is supported by the Australian fertilizer and dairy industries and aims to provide a structured approach for best nutrient management practices on dairy farms to optimise productivity, improve NUE and reduce nutrient losses. The dairy NMP is underpinned by sound science, integrates individual farm information, and ensures consistency and quality assurance of the nutrient management advice provided by dairy industry and Fertcare Accredited Advisors.

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