PLUGGING THE LEAKS – HOW FERTILISER MANAGEMENT HELPS REDUCE N AND P LOSSES FROM DAIRY FARMS

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Introduction

Retaining your social licence to dairy farm increasingly requires you to reduce the off farm impacts of your activities on the surrounding environment. Given the current focus of central and local government on maintaining or enhancing ground and surface water quality, dairy farmers should minimise, where possible, nitrogen (N) and phosphorus (P) losses from their farms. Obviously, N and P fertiliser applications add these nutrients to farm systems to increase or maintain pasture and forage crop production and so may contribute either directly or indirectly to losses of these nutrients from your farm to the environment.

The purpose of this paper is to discuss ways of reducing **direct** losses of nutrients from fertiliser to the environment. Direct fertiliser losses are relatively low, provided that good management practices are employed when using fertilisers on farm.

Nitrogen cycling on dairy farms

Nitrogen fertiliser, legume N fixation (Figure 1) and bought in feed are the main external sources of N supply to your farm. However, much of the legume N and the supplementary feed N enters the soil through the breakdown (mineralisation) of dung, urine and plant residues (Figure 1). The biochemical processes of mineralisation, nitrification and denitrification, mediated by soil microorganisms, then converts all sources of N into ammonium and nitrate ions which are then able to be used by plants but also can be prone to gaseous or leaching loss from the soil (Figure 1).

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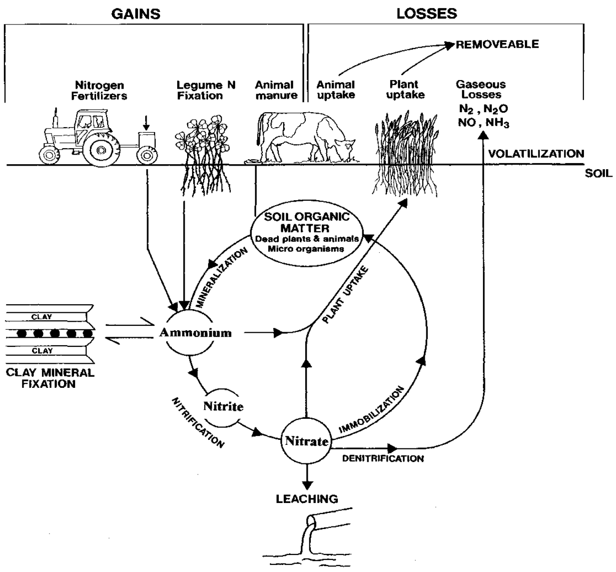

Figure 1: Diagram of the N cycle in agricultural systems (from McLaren and Cameron, 1996)

Indirect N losses

The major source of nitrate (NO_3^-) leached in grazed pastures is the N returned in urine from the grazing animal (Di and Cameron, 2005) and as some of the urinary N may have been derived from animals grazing N fertilised pasture, this constitutes indirect fertiliser N loss. Indirect N loss is arguably more difficult to tackle because of the complex nature of farm systems and the interaction of N fertiliser with those systems (Shepherd and Lucci, 2011). In order to reduce these losses there is a wide range of management practices and system changes that are being researched or have been implemented by farmers to increase the N efficiency of grazed pastoral systems (Monaghan *et al.* 2007; De Klein et al. 2010).

Direct N losses from fertiliser

Gaseous losses

Direct N fertiliser losses arise after fertiliser application and could be as gaseous losses (ammonia, nitrous oxide or nitrogen gas) by volatilisation (Figure 1) or leaching loss of N from fertiliser granules. Enhanced efficiency fertilisers (EEFs) are being produced by companies manufacturing and marketing N fertilisers to farmers. Urea fertiliser, in particular, can lose N content as ammonia gas during the dissolution (hydrolysis) of urea after application with New Zealand trial work showing an annual average N loss of 15% with a range 7-20% (Bishop and Manning, 2011; Sherlock *et al.* 2011). A urease inhibitor N-[n-butyl] thiophosphoric triamide (NBPT) coated onto urea fertiliser has been shown to decrease ammonia volatilisation from urea fertiliser (Watson, 2000) by an average of 50% in New Zealand pastoral conditions (Sherlock *et al.* 2011; Zaman *et al.* 2013). Volatilisation losses of urea fertiliser may also be effectively reduced by applying low rates of application (e.g., 30-50 kg N/ha) to pastures with reasonable cover and which receives at least 10mm rainfall or irrigation within 8 hours of application.

Nitrous oxides are of less agronomic importance, being a very small proportion of losses of applied N, but are clearly important as a potent greenhouse gas. The use of dicyandiamide (DCD) has been shown to decrease nitrous oxide losses from urea by slowing nitrification (Zaman *et al*., 2008). Currently, DCD is not used in New Zealand because of potential food residue issues.

While minimising direct gaseous losses of N fertiliser will improve N fertiliser use efficiency i.e., potentially, a farmer will get a better response to the N fertiliser applied and may contribute in a minor way to reducing greenhouse gas emissions, these losses represent a very minor contribution of N loss to the environment.

Leaching losses

Risk of loss of N fertiliser by leaching can be minimised by good fertiliser management practice. If soluble N fertilisers are applied to wet soils which then receive enough rainfall or irrigation to induce drainage, then some of that nitrogen will be lost in the drainage water. In particular, avoiding application in the winter months when growth rates are slow and drainage through the soil can leach, fertiliser N has been shown to be important (Ledgard, 1986). Losses potentially can be large (Figure 2) and reported to be as much as 30-50% of N fertiliser from winter applications (May-July) in the Waikato (Ledgard, 1989) and Canterbury (Cookson *et al.,* 2001).

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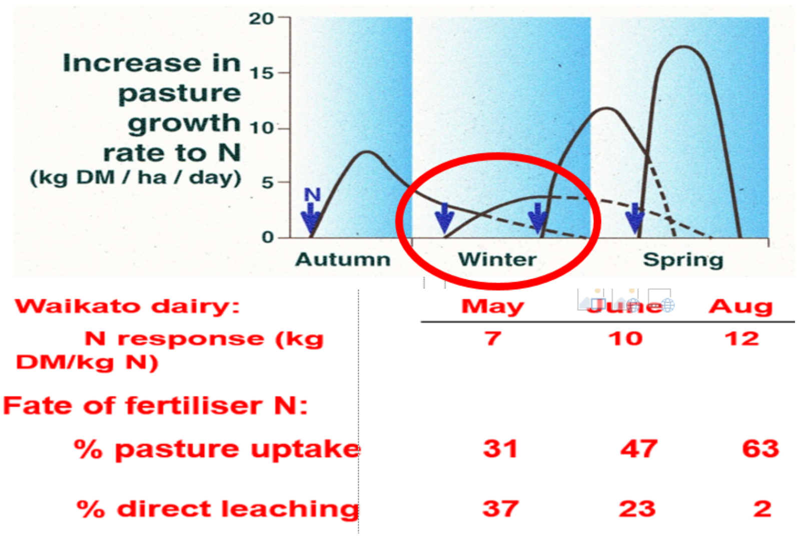

Figure 2: Leaching losses and timing of fertiliser N application (adapted from Ledgard, 1989)

Phosphorus cycling in grazed pasture

Phosphorus inputs onto the soils of your farm primarily come from fertiliser P, animal manure and supplementary feed (Figure 3). Like N fertiliser, there are both direct and indirect losses of fertiliser P.

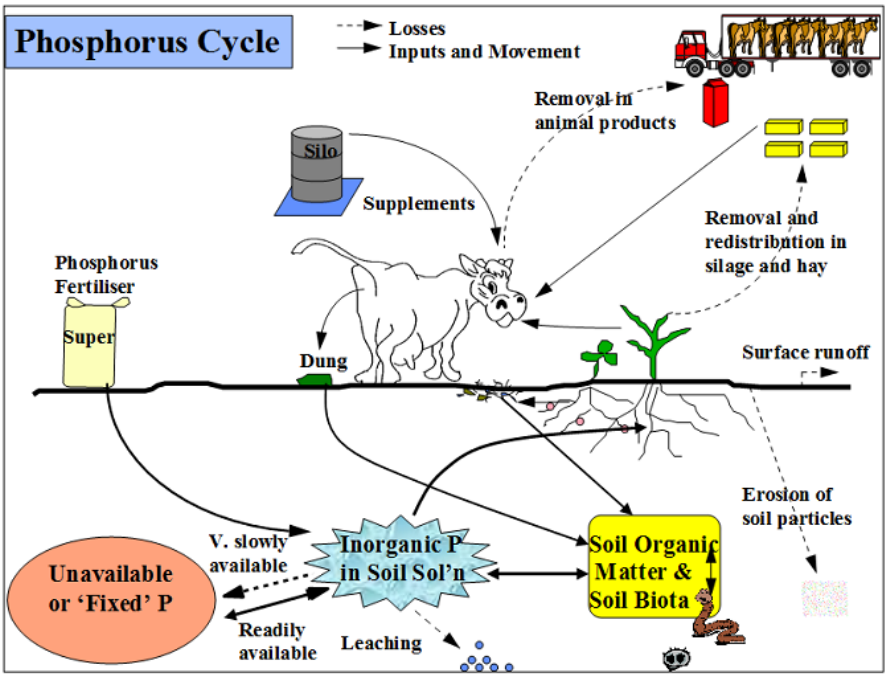

Figure 3: The phosphorus cycle in grazed pasture

Indirect P losses

In pastures grazed by dairy cattle, indirect losses of P from soil account for about 30-50% of total paddock losses (McDowell *et al.,* 2007). Where soils are potentially erosion prone, soil-P losses may account for more (i.e. nearer 50%) of paddock P losses compared to stable soils.

Direct P losses from fertiliser

Timing and form of P application

If good practice is followed, direct fertiliser P losses are relatively small i.e., less than 10% of total P lost from pastures (McDowell *et al.,* 2007a). For fertiliser P to be transported by overland flow into waterways, the soil has to be saturated and the rainfall intensity has to be high enough for runoff to occur before the fertiliser P has had the opportunity to be washed into the soil. Surface runoff travels only about 20m in a worst-case scenario (e.g., dry soil, heavy rain) and soil structure and type, pugging and pasture cover are important factors governing P loss via overland flow.

However, if good practice is not followed, then P losses from fertilisers can account for the majority of P losses from a farm. For example, between 1.2 and 3.4 kg P/ha was lost from a 50 kg P/ha winter application (as superphosphate) on a pallic soil in either overland flow or soil drainage (Sharpley and Syers, 1979). Generally, the potential for soluble P fertilisers to be lost in either overland flow or drainage reduces quickly with time after application. Within 30-60 days the P lost from soil with soluble P fertiliser applied will equal the same as soil with no soluble P fertiliser applied (McDowell et al., 2003). However, the potential soon after application is directly related to the solubility of the fertiliser applied (Figure 4) with the risk of direct P loss in the order superphosphate > serpentine super > reactive phosphate rock (McDowell and Condron, 2004; McDowell and Catto, 2005).

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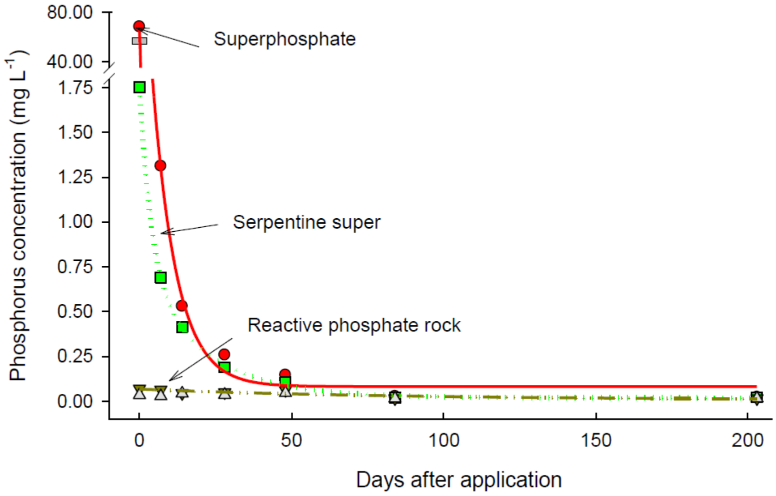

Figure 4: Comparison between solubility of different P fertiliser forms and potential for P loss risk.

McDowell *et al*. (2003) has indicated that within the first 60 days of superphosphate application, if a significant storm event occurs that causes overland flow, the concentration of dissolved P could be high enough to contribute to water quality problems from land closely adjoining streams. In this situation, the loss of P from RPR will be much lower and will not significantly contribute to poor water quality over the same time period (60 days). Over the longer term, P losses are likely to be the same regardless of fertiliser type. In some environments, storms only occur 3-4 times per year during predictable times. Where storms are more frequent, the timing is less easy to predict and for fertilised land in close proximity of a P-sensitive water body, then RPR application will reduce the risk of direct P loss from fertiliser over that first 60-day risk period. The economics of using RPR in comparison to superphosphate should also be considered when balancing farm productivity with environmental impacts.

Optimum Olsen P levels

Soil Olsen P should be maintained within the range of concentrations considered optimal for pasture production and not excessive for any given soil type. Since the magnitude of P losses from soil via overland or subsurface flow is proportional to soil P concentration (McDowell *et al*., 2003), having an Olsen P concentration above optimum represents an unnecessary source of P loss and an unnecessary waste of the fertiliser P inputs. However, maintaining optimal soil Olsen P does not totally prevent P losses from occurring. Some soils can lose a lot of P at optimal Olsen P concentrations for pasture production e.g., soils with little Al and Fe oxides such as Podzols (McDowell and Condron, 2004). Furthermore, if a soil is already P-enriched then it can take many years for Olsen P to decline unless soil is cultivated, perhaps during cropping or regrassing, to remove surface enrichment and redistribute P within the plough layer (Sharpley, 2003). The risk of P loss from generating high soil Olsen P levels is greater on soils which have a lesser ability to retain fertiliser P additions. The ability of soils to retain P is measured by the anion storage capacity (ASC) laboratory test. There is less P lost in overland flow on soils with higher ASC values than those with lower ASC values at the equivalent Olsen P test level (Morton *et al.* 2003).

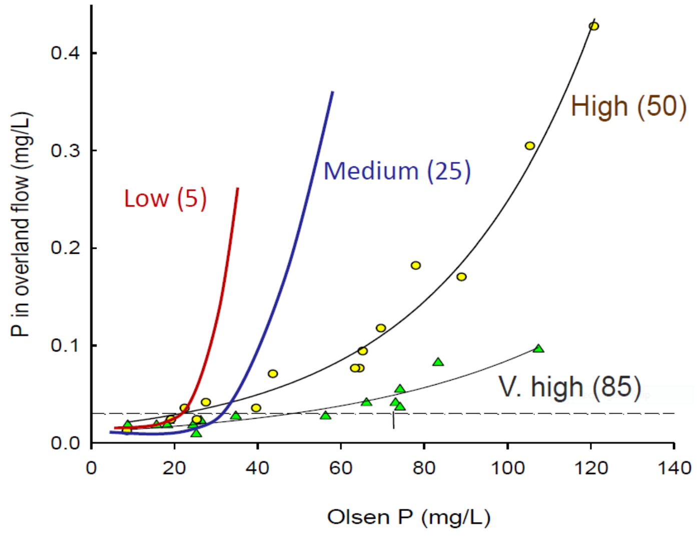

Figure 5: The relationship between soil Olsen P and P loss as influenced by anion storage capacity (in brackets). Dotted line is the water quality limit for P in surface water.

Conclusions

The direct losses of the nutrients N and P, which are both essential for productive dairy farms but of environmental concern if they end up in surface and ground water, from fertiliser applications can be minimised if good practice around fertiliser applications is followed on farm. This good management practice can be encapsulated by the following: right product, right time, right rate and right place. After that the greatest losses of N and P will come from the farm system itself in terms of N in animal urine patches and P loss caused by sediment and dung movement to surface water. To reduce these losses on farm may require greater or lesser farm system changes depending on individual farm physical, climatic and management factors.

Notes:

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