Environmentally Friendly Fertiliser Management

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Introduction

The environment is sensitive to the injudicious use of fertilisers. The Resource Management Act, which promotes the sustainable management of natural and physical resources, says (section 17) that every person has a duty to avoid, remedy or mitigate any adverse effect on the environment arising from any activity. To ensure that fertilisers are used safely and effectively within New Zealand farming systems, the Fertiliser Code of Practice has been developed to provide guidelines for sustainable fertiliser use as provided for in the RMA. The New Zealand Dairy Industry has also introduced an on-farm Quality Assurance programme called "Market Focussed" to assist dairy farmers to adopt management practices that help the industry to comply with environmental standards set by the market or regulatory authorities. Both documents seek to ensure that fertilisers are used to optimise pasture production whilst avoiding unnecessary or excessive leaching or overland flow from the soil.
This involves:

- Establishing a farm nutrient plan that identifies target soil test ranges and maintenance nutrient inputs to the farm.
- Identifying Best Management Practices appropriate to each farm that can minimise losses of these nutrients.
- Establishing a monitoring protocol to ensure that the nutrients are not accumulating or declining within the soil. In this paper we shall outline some of the specific guidelines relating to each of these steps, with a particular focus on P fertiliser inputs.

Monitoring by Environment Southland over the last five years has shown that nitrate-N levels in most of the main rivers are well above surface water quality or ecosystem guidelines (Crawford 2001). Secondary streams such as the Makarewa and Waihopai Rivers, Otautau Stream and Waituna Creek have even higher nitrate levels because of less dilution, and because the streams flow through more highly developed land. P concentrations are below the water quality guideline for all of the main rivers except the lower Mataura. For these rivers, nuisance weed growth is currently limited by a lack of phosphorus, but this may be short-lived if P levels continue to rise, as observed at present. In the above secondary streams, phosphorus levels are one to three times greater than the water quality guidelines.

Groundwater nitrate-N levels in lower Southland catchments also appear to have shown a steady increase since 1998. Many shallow aquifers in Canterbury have nitrate concentrations above 10 mg N/L, although the deeper aquifers remain at very low nitrate levels. A high concentration of nitrate in drinking water is a health hazard, particularly for young infants. The New Zealand Department of Health has therefore set a maximum acceptable value of 11.3 mg N/L for drinking water in New Zealand.

Although dairy farming is not the only source of P and N in watercourses and nitrate-N in groundwater, the increases in Southland levels in the last five years has occurred during a rapid expansion in dairy farming.

Phosphorus

Target Olsen P ranges

Weed and algal growth in surface waters in Southland and Otago is generally limited by low levels of P rather than N. Therefore, this paper will mainly focus on managements to minimise P losses from dairy farms and thus reduce the risk of excessive weed and algal growth occurring in rivers and lakes.

Fortunately, most of the available research shows that the recommended target ranges of soil Olsen P for economically optimal milksolids production are below the high levels that cause environmental problems. From the trial results, it is recommended that soil Olsen P be maintained at 20 - 30 where milksolids production per ha is average for the supply area. If milk solids production per ha is in the top 25% for the supply area, or it is intended to increase to that level, economic responses can be achieved at Olsen P levels between 30 - 40. There is little or no benefit to pasture production above these soil test levels, however there is a significant environmental risk.

On some dairy farms where milksolids production does not change greatly from year to year, Olsen P levels are trending upwards, beyond these target ranges. As the levels increase, more P is attached to particles of soil that can be potentially lost in run-off to watercourses. This situation is shown for an actual farm example in Figure 1 below.

In this case, maintenance fertiliser P application rates were higher than required, and Olsen P levels increased above the target range.

Another reason for Olsen P levels to increase above the target ranges is feed containing P being brought onto the milking platform. For example, hay contains 14 kg P/tonne, baleage 10 kg P/tonne (wet) and silage 7 kg P/tonne (wet). The amount of P and other nutrients imported per ha can be estimated using the OVERSEER Nutrient Budgeting programme, and fertiliser nutrient inputs reduced accordingly to prevent increases in soil Olsen P.

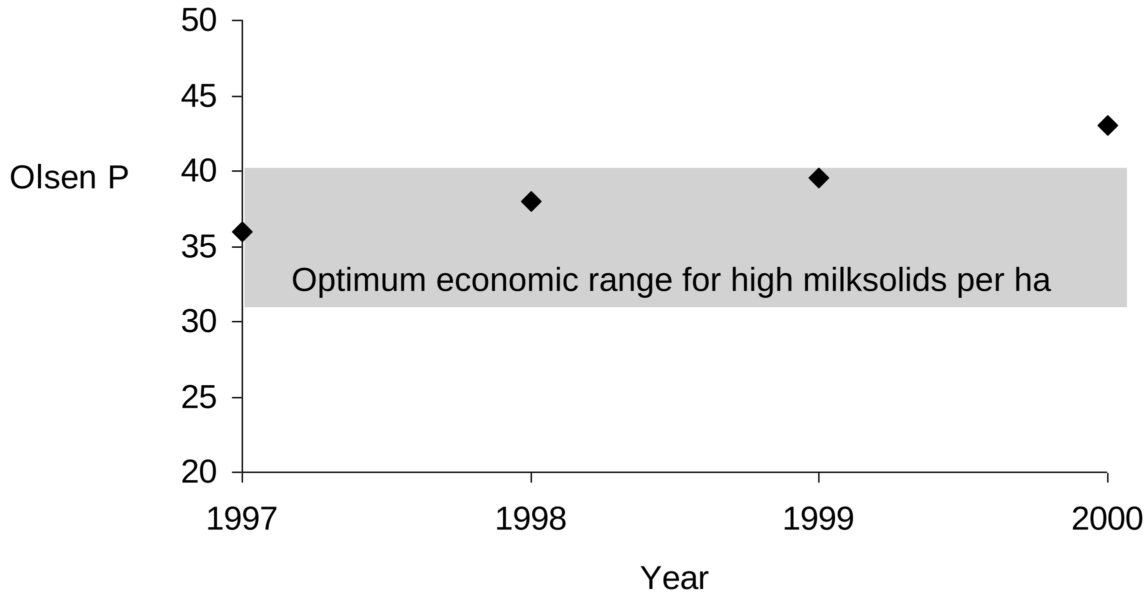

Figure 1: Upward trend in soil Olsen P levels with near constant milk solids production.

Soil damage and P loss

When fertiliser is applied, P is bound to soil particles. If the soil surface is damaged by cattle hooves during wet soil conditions, the soil particles become loose and can be transported in run-off of overland flow into watercourses. At Edendale in Eastern Southland, removal of P in run-off has been measured after grazing in wet conditions during late winter and spring, six to eleven months after fertiliser P was applied in January (Figure 2). There was a much greater P removal where the soil was pugged compared to where the soil remained un-pugged.

Greater annual P losses in runoff due to increased pugging severity has been measured at both the Edendale and Tussock Creek (Central Southland) sites (Figure 3). On the Brown soil with better natural drainage (Edendale), there was no difference in annual P loss on mole and tiled soils where pugging was minimal, at stocking rates between two and three cows/ha. For the undrained treatment at three cows/ha, where pugging did occur, P losses were about seven times as great as the drained treatment at the same stocking rate. On the heavier Pallic soil at Tussock Creek, where cows were left on pasture for the whole grazing period during rainfall events, pugging still occurred even with adequate drainage, resulting in similar P loss to the undrained Edendale soil. However there was a further increase in severity of pugging and P loss where there was no drainage.

Annual P losses greater than 100 - 200 g/ha will usually result in P concentrations in watercourses above the required water quality standard.

Best management practices to minimise nitrate leaching

The main concern regarding nitrate leaching from dairy farms is the contamination of groundwater aquifers that are relied upon for drinking water supplies by rural communities. Groundwater nitrate levels in Southland are trending upwards due to the increasingly more intensive use of pastoral land within the province.

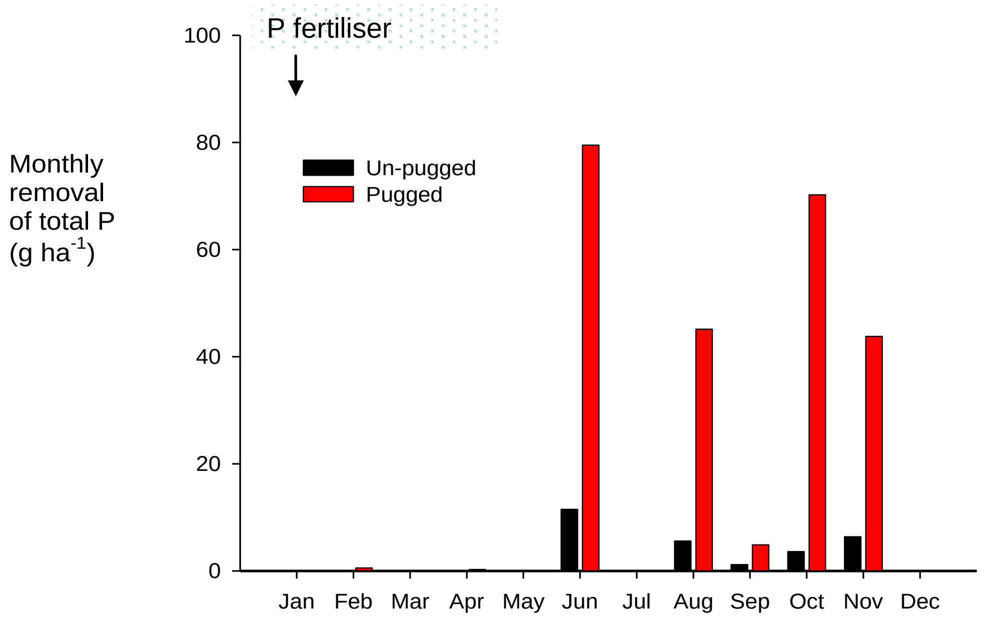

Figure 2: Average monthly losses of P in overland flow (or surface run-off).

The potential for nitrate leaching under dairy pasture is high because only a small amount of the N ingested by the cow is actually removed in the milk, and a large proportion, between 60 - 90%, of the N ingested is returned, in the forms of urine and dung. The N loading rate under a cow urine patch is equivalent to approximately 1000 kg N per ha.

Data from experimental studies in Canterbury, Southland and Otago have been used to develop simple computer models to estimate nitrate leaching losses from dairy pastures. These models can be used to estimate the critical N application rate for grazed pastures. Within the Canterbury region, the models suggest fertiliser application rates above 150-200 kg N/ha/year will cause the concentration of nitrate in the drainage water to exceed the drinking water standard (Di and Cameron, 2001). Within the Southland and Otago regions, the models suggest that rates above 170 kg N/ha/year will result in elevated nitrate concentrations in drainage water (Monaghan *et al*. 2000), although these upper limits vary considerably depending on climate, soil and farm management factors.

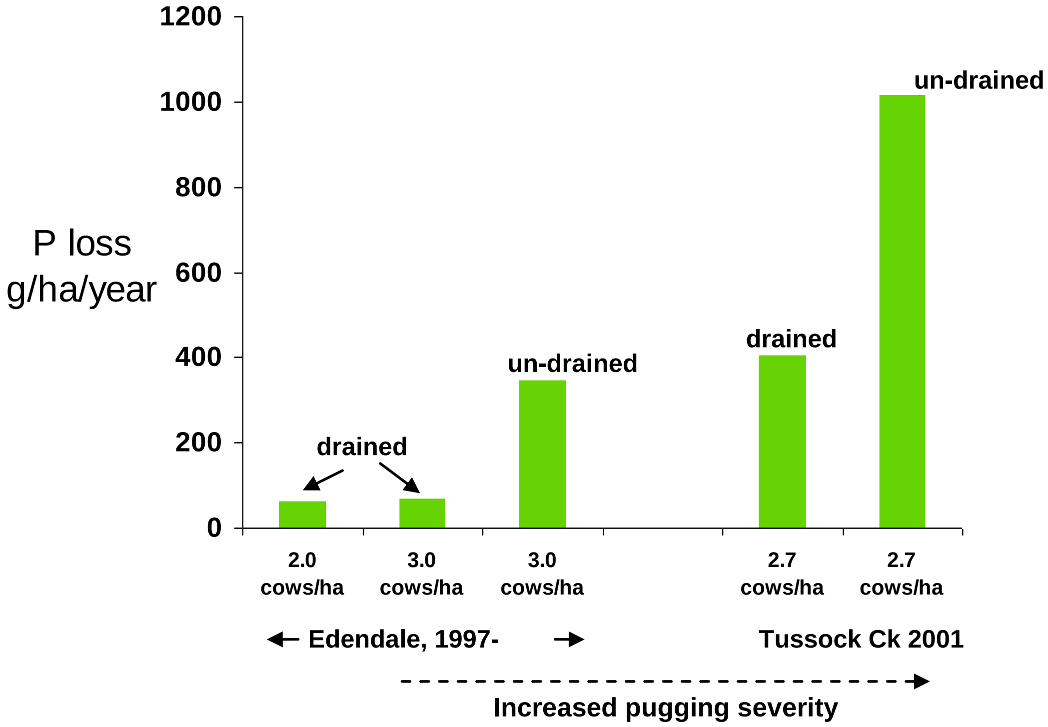

Figure 3: Measured losses of P in overland flow at Edendale (Eastern Southland) and Tussock Creek (Central Southland) study sites.

To ensure that nitrate leaching losses from dairy farms remain within acceptable limits, the following Best Management Practices are recommended:

- Annual inputs of nitrogen fertiliser should not exceed 150 - 200 kg N/ha/year to ensure that nitrate concentrations in drainage water are less than the drinking water quality standard of 11.3 mg nitrate-N/L. This upper limit does depend on soil, climate and farm management factors, so for a more accurate figure use the nutrient budgeting or computer model tools mentioned above.
- Be sure to account for returns of nitrogen (and potassium) via irrigation of dairy shed effluent. These inputs from effluent can be large, and fertiliser inputs to these areas should be reduced accordingly to ensure that total annual inputs do not exceed the figures mentioned above.
- Single N fertiliser applications should not exceed more than 50 kg N/ha so that as much of the N as possible is taken up by the pasture.
- Use soil temperatures as a guide to timing of N application. Apply when soil temperatures are above 4°C in spring and above 7°C in autumn.
- In nitrate-sensitive catchments, the leaching of nitrate-nitrogen from urine patches can be reduced by removing cows to stand-off areas once they have grazed on pasture for four hours during autumn and winter.

The above practices have been established from much recent research carried out in Southland, Otago and Canterbury. For further details refer to MacDonald and Monaghan (2000) and Cameron (1999).

Conclusions

Environmentally friendly fertiliser management for dairy farmers involves the use of Best Management Practices to ensure that there is minimal input of phosphorus (P) and nitrogen (N) into watercourses and groundwater. Fertiliser P should be applied so that Olsen P test levels are in the range 20 - 30 where milksolids production per hectare is average for the supply area, and in the range 30 - 40 if milksolids per hectare is in the top 25% for the supply area. Pugging of soils will greatly increase the loss of phosphorus from pastures to watercourses and thus encourage undesirable weed growth in rivers and lakes. Excessive treading of wet soils should be avoided by on / off grazing and the use of feed pads or stand-off areas. To ensure that nitrate-N concentration in drinking water sourced from groundwater is less than 11.3 mg/litre, fertiliser N applications should be limited to less than about 150 - 200 kg/ha per year, with single dressings of no more than 50 kg N/ha. In nitrate-sensitive catchments, the leaching of nitrate-nitrogen from urine patches can be reduced by removing cows to stand-off areas once they have grazed on pasture for four hours during autumn and winter. When P or N fertiliser is applied, any direct application into watercourses should be avoided.

References

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Workshop summary

Presentation summary

Issues P promotes weed and algal growth and N affects drinking water.

- Involves the use of Best Management practices to ensure that there is a minimal input of phosphorus (P) and nitrogen (N) into watercourses and groundwater.
- Apply P to maintain Olsen P levels for milksolids production / ha in the range of 20 - 30 for average production and 30 - 40 for the top 25% of the supply area.
- Pugging greatly increases P losses to watercourses and encourages undesirable weed growth.
- Avoid excessive treading by on / off grazing, use of feed pads or stand-off areas.

- Limit N applications to less than 170 kg N/year and 50 kgN/application to ensure the concentration in drinking water sourced from ground water is less than 11.3 mg/litre.
- During autumn and winter remove cows to stand-off areas after four hours grazing to reduce urine patch nitrate N. Can ½ N loss.
- Avoid direct applications of P or N into watercourses.
- To avoid leaching and overflow:
  - Establish a farm nutrient plan that identifies target soil test ranges and maintenance nutrient inputs to the farm.
  - Identify Best Management Practices appropriate to each farm that can minimise losses.
  - Establishing a monitoring protocol to ensure that the nutrients are not accumulating or declining in the soil.
- Soil temperature guidelines for timing N are above 4^{O} C in spring and 7^{O} C in autumn.
- Bought in feed adds nutrients to the system e.g. -P.

Discussion summary

- Apply N just before active growth months.
- Other contaminates causing N losses are N from birds, laneways and wintering pads.
- Avoid N applications for two to three days after hard grazings. >1000 kgDM/ha or
- < 25mm.
- Miniming losses - Back fencing, fence streams. Don't apply to pugged soils.
- 1/3 free P losses, 2/3 from P attached to particles which have run-off.
- The size of grass buffers to avoid runoff depends on Soil type, contour, crop type, intensification of land use etc. Site specific. Flat 3 - 4 m, Rolling 6 - 8 m.
- Lose ½ kg P/ha - $ value not great but has big environmental impact.
- N and P use voluntary. If we take a cooperative approach you shouldn't need to regulate.
- Bare soils = greater run-off.
- Top ¼ farmers have the management ability to capture the benefits from higher Olsen Ps.
- Average farmers grow as much grass but lacks ability to capture it, no point raising P levels.
- Capture stand-off run-off into effluent ponds.
- Pad design is important, otherwise you are only transferring the problem.
- Low to moderate rates of N use losses are moderate < 150 kg N /ha/year.
- Do nutrient budgets, e.g. Overseer - Fertiliser sales reps. have it.
- Lot of N lost from autumn urine N.
- With subsoiling if you don't have additional drainage it can recompact.
- Difficult to prevent P loss from tile drains.
- N fertiliser use two to three days before grazing of but no longer otherwise too big an N build up in plant.
- Crops apply 50 kgN/application two to three times over crop life.
- K has no detriment to the environment or animal health but effects cow health.
- Could be stronger guidelines for cows per ha in the future. Market focussed.