INTEGRATED NUTRIENT MANAGEMENT STRATEGIES FOR DAIRY AND CROPPING FARMERS

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Background

Many dairy farmers apply pond effluent collected from the milking shed and feed platform back to their paddocks. Land application is standard practice in New Zealand, but repeated irrigation with this nutrient-dense effluent can cause the soil to become overloaded with nitrogen (N), phosphorus (P) and potassium (K). Negative effects on animal health (grass staggers) as well as on the environment (leaching, eutrophication) may occur as a consequence. Opportunities exist to mitigate such impacts by more closely integrating nutrient management strategies of dairy and cropping farmers to create win-win outcomes for both sectors. To achieve this outcome there are two key strategies. Firstly, farmers can use crops to recover nutrients on higher fertility blocks that have had a long history of permanent pasture and effluent irrigation. Depending on the subsequent feeding regime, the nutrients removed by these crops will either be returned to the soil surface during grazing or exported from the paddock if taken for silage. Secondly, strategic use of pond effluent can also markedly reduce the amount of synthetic fertiliser necessary on lower fertility cropping blocks. Over the past 5 years we have undertaken a number of trials to investigate the performance of these two strategies. This paper summarises key observations during this time.

Strategy 1: Using crops to recycle nutrients on high fertility dairy blocks

What have we done?

During the 2007–08 and 2008–09 summer seasons we conducted seven trials in the Waikato region to investigate the ability of silage maize to recycle nutrients from high fertility dairy soils (referred to as first season trials). All of the trials were conducted in farmer paddocks that had a history of permanent pasture (~10 years) with either regular effluent irrigation or very high stocking rates (up to 7 cows/ha) and were being cropped for the first time. In all trials we compared a no N fertiliser practice to each farmer's standard fertiliser practice, which was either starter fertiliser only (36–45 kg N/ha), or starter plus side dress fertiliser (64–149 kg N/ha). Our goal was to achieve similar yields to the farmer's standard practice without the cost or additional nutrient loading from fertiliser. During the 2009–10 summer season we conducted follow up trials in two of these first season paddocks to investigate if the potential nutrient benefit lasted for consecutive cropping seasons with no extra N fertiliser (referred to as second season trials). In between the seasons (May 2009 – October 2009) winter grass was planted at both sites to ensure there were minimal loses of N. No extra N fertiliser was applied to the grass. Three fertiliser practices were compared in these second season trials, including a no N fertiliser practice, starter only fertiliser (36 kg N/ha), or starter plus side dress fertiliser (128 kg N/ha). With the exception of nutrient management, all other crop management decisions were made by each farmer. A wide range of growing environments, soils and production practices were covered.

What have we found?
In all of the first season trials we found that silage maize could be successfully grown without additional N fertiliser inputs in these high fertility dairy soils. Across sites and seasons, silage yield in the no N fertiliser control averaged 26.3 t DM/ha and the farmer practice 26.5 t DM/ha. These reflected above average maize yield potentials, so there was strong demand for nutrients. Average nutrient uptake in the no fertiliser control was 297 kg N, 44 kg P and 384 kg K/ha, all of which was supplied from soil reserves. Importantly, the farmer fertiliser practices applied about 30–150 kg N/ha in extra fertiliser, which was of no economic value to the crop. There was also no crop response to P fertiliser that was applied in mixed N/P starters (soil Olsen P at sowing ranged from 26 to 92 mg/L across sites, well above the likely threshold for a crop response). In most cases soil mineral N in the top 60 cm at harvest was similar to or higher than that measured at sowing in the no fertiliser plots; this was despite an average of 297 kg N/ha being removed by crops that received no N fertiliser. This confirmed significant N release following the cultivation of these first season paddocks.

In the second year trials (i.e. two consecutive seasons of cropping) we found that silage yields were maximised either with the no fertiliser (0 kg N/ha for two seasons) or with the starter fertiliser only approach (0 kg N/ha in the first season, and 36 kg N/ha in the second season). Silage yields were 28 t DM and 31 t DM/ha at the two sites, again representing above average yield potentials. There was no yield benefit from the full fertiliser approach at either site. At harvest, there were still moderate levels of soil mineral N in the top 60 cm in no fertiliser plots (35–65 kg N/ha). This indicated that these soils were still mineralising significant amounts of N after two consecutive seasons of cropping. When summed across the two seasons, crop uptake in the no N fertiliser control totalled 607–657 kg N/ha, all of which was supplied from the soil reserves.

What can it mean to farmers?
These trials showed that synthetic fertiliser application (starter or side dress N) was unnecessary to maximise silage yields in dairy paddocks with a history of permanent pasture and regular effluent irrigation. This response was consistent for a number of different locations, soil types and production practices. Potential cost savings to farmers are high (up to $400/ha, depending on fertiliser practice), representing about 10–20% of the total cost of maize production. In some cases the effluent treated soil may also supply enough N to maintain high yielding crops beyond the first season with little or no N supplementary fertiliser applied. Because the loading of P and K is already high in many dairy soils further applications (e.g. base or starter fertiliser) of these nutrients are unlikely to increase crop yields.

One approach to decide if maize crops require additional N (particularly in the second season) is to use a nutrient budgeting tool such as AmaizeN. AmaizeN accounts for soil measured mineral N, predicts new N that will be mineralised from the soil during the season, and considers the effects of weather and production practices on the likely crop yield (and therefore N demand). Because pasture residues take time to break down and release N, collecting soil mineral N samples around the time side dressings are applied is recommended.

Strategy 2: Using effluent as a nutrient source for crops on nutrient-depleted soils

What have we done?

Preliminary trials in the Waikato showed that there is potential to use nutrient-rich effluent to help meet crop N demand on nutrient-depleted soils. However, the rate and amount of N released from effluent can vary significantly based on initial effluent characteristics and subsequent field conditions. During the 2009–10 and 2010–11 summer seasons we conducted a trial to monitor the release of N from pond effluent in the first and second season after application. The trial site had a history of cropping and very low soil N status. In the first summer season we compared the performance of maize under three key nutrient treatments, including a no N fertiliser control, an optimal rate of fertiliser (150 kg N/ha, based on an AmaizeN nutrient budget) and our best estimate of an optimal effluent rate (300 kg N/ha). The effluent rate was 2x the fertiliser rate based on the prediction that no more than 50% of the effluent N would likely be released in the first season (based on earlier findings). With the exception of nutrient management the crop was grown to standard practice and subsequently harvested for grain. Winter grass was then immediately sown. The grass received no extra N fertiliser and was not grazed. In the second summer season the control, effluent and fertiliser treatments were retained. However, there was no new effluent application in the respective effluent plots, as the goal was to quantify the longer term release from the effluent that had been applied the previous season. An AmaizeN nutrient budget was used to determine the optimal fertiliser rate (115 kg N/ha). As in the first season, maize was grown to standard practice and subsequently harvested for maize silage.

What have we found?

In the first season we found that maize grain yields were comparable between the effluent and fertiliser treatments (14.0 and 13.3 t/ha, respectively). Maize grown in the control treatment was N deficient and yielded significantly less (only 10 t/ha) than the other treatments. An estimate of the N recovered from effluent in the first season was made using soil mineral N data at sowing and harvest (to 60 cm) as well as final crop N uptake. This was adjusted for the supply of N from the control treatment (as an estimate of mineralisation of N unrelated to effluent application). Based on this calculation, recovery was lower than anticipated (~30%, but still comparable to several earlier trials). This indicated that a major component of the effluent was either still in the soil (as more stable organic N forms) or had been lost from the system. In the second cropping season a maximum of 210 kg N/ha (i.e. 70% of 300 kg N/ha) from the initial effluent application could have still been in the soil. However, maize silage yields were comparable between the control and previous effluent treatment (12.2 t DM and 13.0 t DM/ha, respectively). This suggested that there was either very little residual effluent N in the soil as initially estimated, or that it was released in such small amounts that we could not measure it using this approach. Although the fertiliser treatment yielded significantly higher (17.0 t DM/ha) than the control and effluent treatments, the overall performance of the crop was poor. This reflected a dry summer season, which resulted in drought conditions during key growth periods. In turn, this may have also affected the mineralisation of effluent N contained in organic forms.

What can it mean to farmers?

These results show the potential of using nutrient-rich effluent to meet crop N demand. However, patterns of release and potential loses to the environment are still difficult to predict. Across five on-farm trials we have estimated that the recovery of N in the first season after application is between 20 and 50%. Improved understanding of the links between initial effluent characteristics, losses and recovery are essential if farmers are to use this resource efficiently. This is especially true in light of regional regulations limiting the amount of effluent N that can be applied each year (e.g. in the Waikato region farmers can only apply 200 kg N/ha/year). A slow pattern of N release from effluent may mean that crops need additional fertiliser N to maximise productivity. The longer term supply of N from effluent in the second season after application remains unclear. New trials are underway to better characterise these patterns.

Overall summary

Collectively, trials under both strategies (using crops to recycle nutrients on high fertility dairy blocks and using effluent as a nutrient source for crops on nutrient-depleted soils) are highlighting the potential to integrate nutrient management strategies on dairy and cropping farms. For dairy farmers this helps to reduce nutrient overloading and potential productivity and environmental concerns. For cropping farmers this helps to reduce the cost and footprint associated with fertiliser use. To support adoption of these strategies, comprehensive best management practices for growing crops on dairy farms have been compiled in an industry publication that is freely available.

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