The case for exploring smart N management on Australian dairy farms

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Two projects investigating nitrogen (N) management on Australian dairy farms were completed in 2009/2010. Both projects indicated that gains in N use efficiency were needed. Results obtained in the Greener Pastures project, conducted in Western Australia, have been communicated to the Western Australian dairy industry but those obtained in a national project entitled "Accounting for Nutrients on Australian Dairy Farms", that included five Western Australian dairy farms, has had limited dissemination locally (see www.accounting4nutrients.com.au). The lead scientists were Cameron Gourley and Sharon Aarons (Vic DPI), Warwick Dougherty (NSW Agriculture) and David Weaver (DAFWA).

"Accounting for Nutrients" quantified farm level imports and exports for all major nutrients (N, P, K, S, Ca and Mg), it examined the redistribution of nutrients between paddocks and established the time cows spent in different management zones on farm. The forty-four dairy farms studied covered the range in environments and management systems used for dairying in Australia.

Nutrient imports were assessed in feed supplements, level of nutrient applied in fertiliser, nitrogen fixation by legumes in pasture, nutrients in irrigation water and in rainfall plus nutrients imported through livestock. Nutrient outputs were assessed in milk, livestock leaving the farm and feed exported off-farm. Monitoring and sampling commenced in February 2008 and occurred over 12 months.

Generation of nutrient surpluses

Import of all major nutrients was in excess of export in conventional farms that used fertilisers. In contrast, organic farms typically removed more soil P than applied. Of note was the surplus of N across all dairy units. This ranged from 47 kg N/ha for dairies based on either conventional or organic farming principles to as much as 600 kg N/ha for a dairy farm with 91% of the pasture irrigated and 61% of the feed supplied to cows purchased off-farm. Twenty-one farms had N surpluses in excess of 200 kg N/ha; the four Western Australian conventionally-managed dairy farms had surpluses of N in the range of 230-280 kg N/ha.

Another important measure is the percentage of N imported that is exported in milk, termed here as the whole-farm N use efficiency as outlined in the following equation:

(N in milk/total N imported) x 100

Whole-farm N use efficiency was as low as 14% and as high 50%; averaged across 41 farms it was ~28% of the N imported. N use efficiency ranged between 18 and 24% for the five Western Australian farms.

Analyses of N use efficiency on ten WA farms in 2009 as part of the Nutrient Management Systems Project run by Western Dairy showed that, on average, N use efficiency was higher than observed in the Accounting for Nutrients project (Figure 1). Nevertheless, there is need to further increase N use efficiency using profitable management.

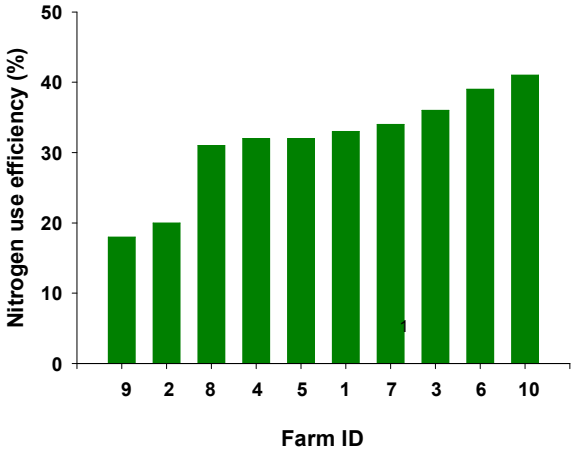

Figure 1. Whole-farm N-use efficiencies for 10 Western Australian dairy farms using 2009 data. Farms with N use efficiencies less than 20% were characterised by large importation of feed from off-farm. N use efficiency averaged over the ten farms was 32%. Sam Taylor, unpublished data.

How can the imported N be used more efficiently? One strategy could be to sharply reduce inputs of fertiliser N and grain N. However, milk production in the 'Accounting for Nutrients' study was strongly related to N input and it is conceivable that a blanket reduction in N input could impact negatively on profitability.

What is required is smart N use where fertiliser N inputs to paddocks or zones within paddocks are adjusted to take into account the capacity of soil to supply N or inputs are adjusted in accordance with the capacity of the land unit to grow pasture.

Another strategy is to recycle nutrients excreted by cows. The Accounting for Nutrients project showed that on average cows spent 74% of their time in paddocks, ~2% in the dairy shed and another ~10% in the yards with the balance of time in laneways, holding areas and pads where these are used. For the ten dairy farms used in the 2009 study, on average, 7000 kg of N may have been in shed effluent assuming 12% of N fed to cows was excreted in the milking shed and associated yards. This is an invaluable source of N.

A key challenge is to better recycle N excreted onto land during periods when there is no live pasture to utilise nutrients, and where there is a risk of N loss following the onset of winter rainfall. On-farm use of high nutrient requiring fodder systems needs examination.

Innovative Practices for Efficient and Profitable Use of N Inputs on Dairy Farms

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Background

We run a 200ha intensive irrigated arable farm growing a wide range of crops including wheat, ryegrass, faba beans, carrots, radish and also hemp.

In 2005 while looking for options for diversity we had an opportunity to become 33% equity partners in a 220 ha, 850 cow high-input and high-output dairy farm. In 2010 we increased our holding in the company to become 50% equity partners while also expanding the operation by leasing a further 110ha, allowing us to milk 1100 cows in 2010/2011. This coming season we will be increasing the milking number to 1250. The farm is run by a variable order share-milker at a 25% level and has a staff of 5.

The farm is a pasture-based system and is supplemented with grain, canola meal and silage.

In 2010 along with our daughter Jemma we started Agri Optics New Zealand Ltd, a precision Agricultural company providing services for farmers, fertiliser companies, and machinery companies. We are supplying EM mapping and data management to clients as well as being NZ distributors for Trimble's GreenSeeker®, WeedSeeker® and FarmWorks software.

In 2010 we also started a research company to help with new initiatives in the developments and the patenting of our Smart-N fertiliser application system.

Variability

On farm we are now grid soil testing to locate the variability that exists in our paddocks, some of this is natural but a significant amount man-made. We have had lime spreading that has been less than accurate as often trucks may not have returned to the same areas when returning with additional truck loads. Or they may have run loads out when there has been excess product on the trucks, resulting in some areas with very high pH levels.

The removal of fences and the amalgamation of multiple paddocks for the development of irrigation and large centre pivots also created variability within paddocks. Grid soil sampling has identified the issues in these and allows us to fix all the base variability with the use of variable rate fertiliser applications.

Nutrient Management

Deep nitrogen tests (mineral N plus an estimate of mineralisable N) are undertaken on the cropping farm in most crops in the early spring to be able to accurately assess the total amount of N for each crop for N budgeting. We are also taking soil N tests in the early spring on the dairy farm before the first grazing to assess the available pasture N. Eco N (nitrification inhibitor) is applied in two applications, one in the autumn and the other in late winter, to reduce nitrate leaching and increase pasture growth.

Nutrient budgets are undertaken in conjunction with our fertiliser company. They include all imported nutrients, enabling us to accurately assess our nutrient use. We also use them when looking at our profitability and where we may be able to reduce fertiliser costs. The Overseer Nutrient Budgeting programme is also used to help us assess our farming practises. This is a model which may become a future requirement in New Zealand so we need to better understand how it works.

We have changed our mindset around how we deal with our effluent. It is now seen as a very important part of our nutrient sources, helping us to reduce both our N fertiliser and other fertiliser inputs. We were not happy with our effluent dispersal system so, this season, have changed to a graduated multi-sprinkler system under our centre pivot to maximise the dispersal area and improve the evenness of the spread, reducing the application rate per hectare.

We have reduced the amount of base fertiliser and lime by 45% this season under the effluent dispersal area through the use of grid and zonal soil testing with no reduction in pasture performance.

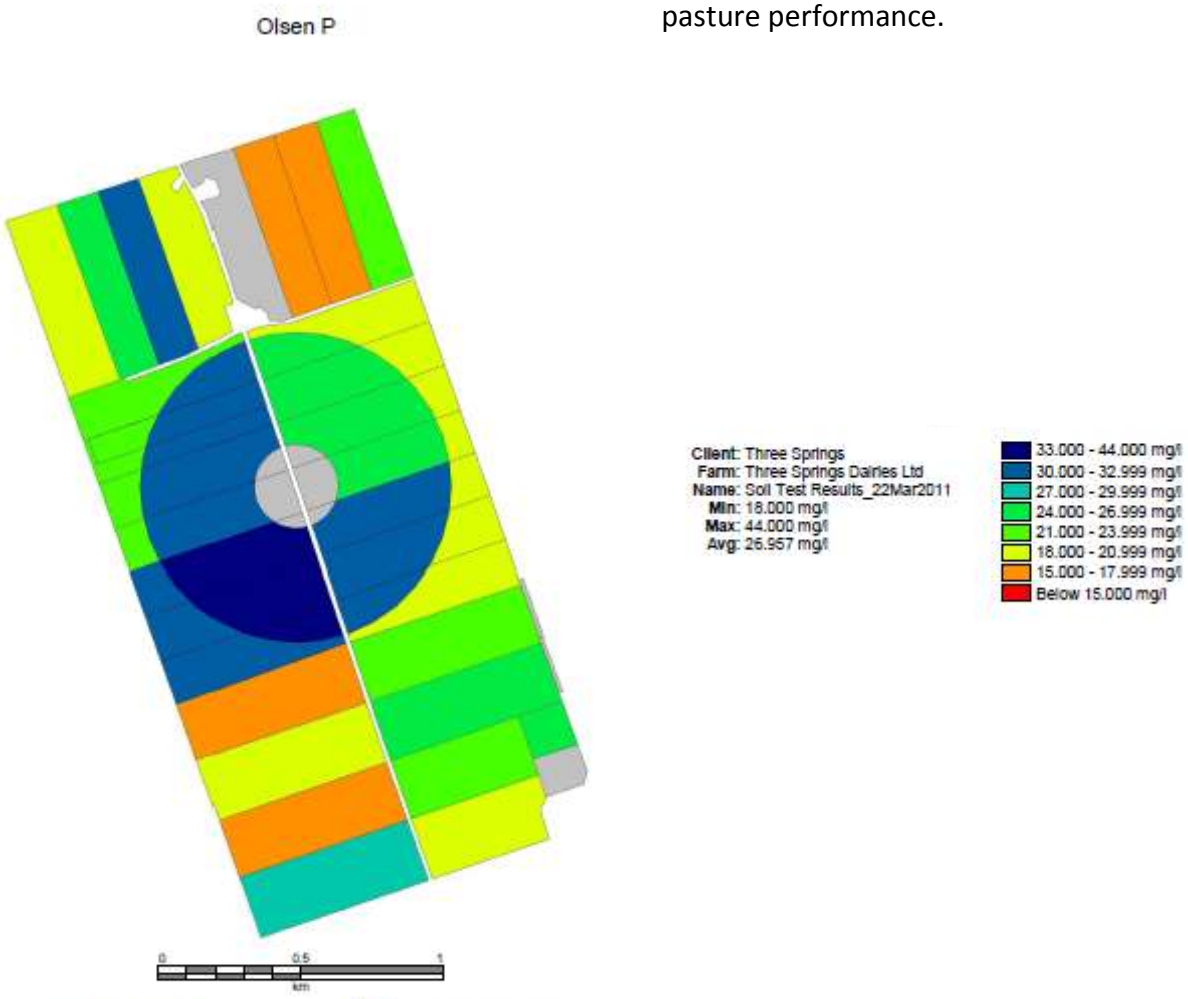

Figure 1. Soil test results showing variation in Olsen P levels.

Mapping

EM mapping is showing us soil variability, identifying areas that have different production potential. Because of this we have the ability to reduce N application in areas that cannot perform as well or being able to avoid areas such as gate ways, stock camp areas and streams with confidence using prescription maps. We are also installing variable rate irrigation this year based on our EM maps, minimising wet lanes to reduce lameness as well as matching our water application to soil type, making our irrigation resource operate more efficiently.

GreenSeeker® equipment is now being used to map the variation in N in season to be able to reduce the amount of N that we require in each individual field throughout the season. We are seeing vast changes in the field, some because of soil variability but often because of stock behaviour and movements.

Over the farm fertiliser N use has been reduced from 300 kg/ha applied to 170 kg/ha this year with a change in the type of fertiliser used. We have seen a large increase in the percentage of clover in our pastures and no reduction in the kilograms of dry matter produced.

GreenSeeker® optical sensor technology enables you to measure, in real time, a crop's nitrogen levels and variably rate apply the "prescribed" nitrogen requirements. GreenSeeker® also predicts yield potential for the crop using the agronomic vegetative index (NDVI). The N recommendation is based on in-season yield potential and the responsiveness of the crop to N. GreenSeeker® is similar to satellite and aerial imagery zone management imagery programmes, however, it is in real time.

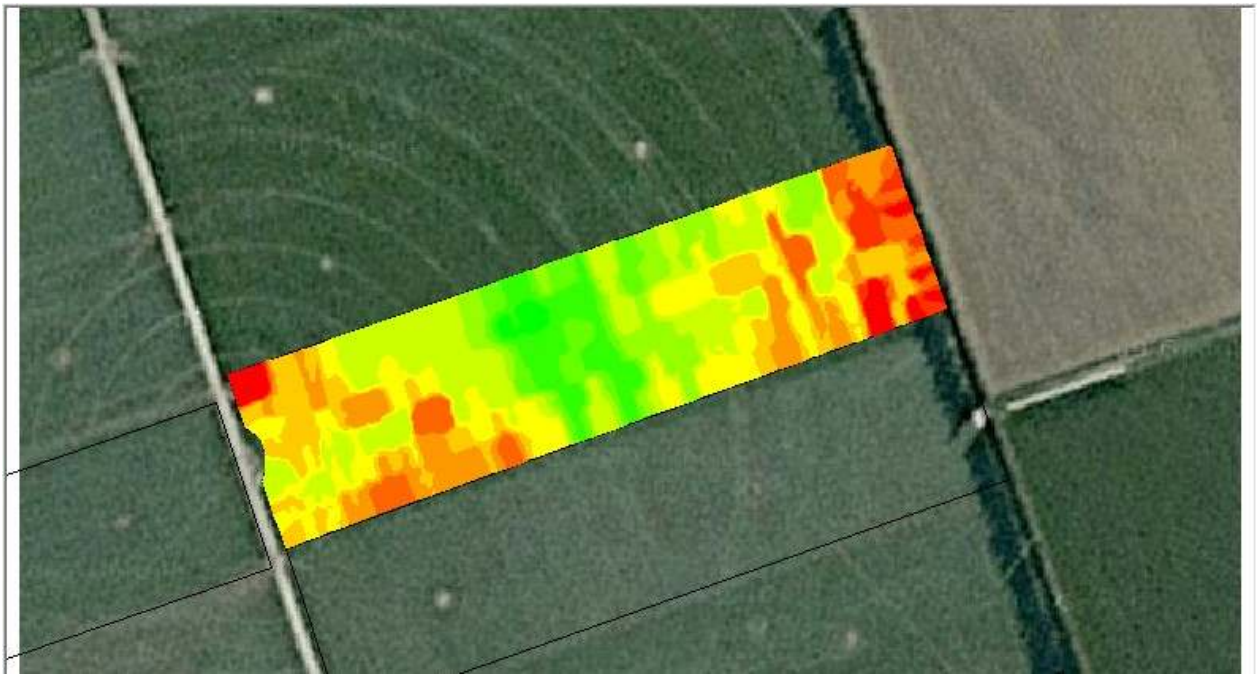

Figure 2: GreenSeeker Map identifying areas of high N loading due to effluent spreading patterns.

Smart-N

Using crop-sensing technology (Weedseeker®) we have developed a process where we can apply liquid N (urea solution with 26% N) between the urine and dung patches and not on them. This system has up to a 30% saving in fertiliser N per application. Along with the 30% cost saving through reduced N application there is also the related reduction in nitrate leaching and reduction in nitrous oxide (N_2O) hence GHG emissions without reduced production. The same system can also be used to apply nitrification inhibitor to urine patches if required.

WeedSeeker® automatic spot spray system uses the same crop sensing technology as GreenSeeker®. Each sensor is linked through a controller to a spray nozzle allowing it to selectively apply herbicides to 'weeds', not bare ground. It is highly effective wherever weeds occur intermittently. WeedSeeker® can also be used to selectively apply fungicides, insecticides, fertilisers and other inputs to targeted plants instead of 'weeds' in a range of applications.

Water/ Irrigation

Water will be the biggest issue that will face the world in the future so its efficient use is very important on a range of levels, politically, environmentally and financially.

On farm, the efficient use water allows us to reduce our impact on the environment. With careful irrigation management we can control the nutrient levels in the soil, matching demand to the plants requirements, keeping fertiliser applications to a minimum. If farmers are not allowed to use water for irrigation there will be a resulting increase in the soil's nutrient bank in the extended dry periods, through the deposits of urine, dung and applied N. In heavy rain events this high nutrient bank creates a huge potential to pollute the environment through its increased potential for nitrate leaching and nitrous oxide fluxes.

Research Initiatives

We work closely with regional and central government and other research providers with research trials looking at improving nutrient efficiency and monitoring of environmental conditions. With the National Institute of Water & Atmospheric Research Ltd (NIWA) we have installed an eddy co-variance tower on the dairy farm to measure CO_2 and N_2O emissions on a working farm. Another multi-party research programme has installed a lysimeter to research the drainage of nutrients to the ground water under an irrigated dairy farm.

These research programmes will allow us to have real measurements for a working farm in NZ and provides more accurate data for an Emissions Trading Scheme (ETS) if agriculture is included in the future.

We need to measure our agricultural practises so we can model them. This will then allow us to mitigate our impact or perceived impacts on the environment.

As we increase production output while reducing our inputs through the use of things like precision agriculture, we will reduce our emissions intensity per kg of product produced. This should help farmers meet our requirements under a pending ETS and improve profitability on farm.

Profitability and good environmental practises go hand in hand so we need to be proactive in this area. If farmers are profitable then it will be possible to invest in technology to help in all areas of sustainability.