Measuring real-time nitrogen loss in cropping

Measuring real-time nitrogen leaching from a tile-drained Hawke's Bay onion field

Why: To compare data from a nitrate sensor installed in situ with data from grab samples, and to establish if in situ measurements could be used as a reliable source of information to enable real-time modification of good agricultural practices so as to reduce nitrate leaching losses.

Where: Vegetable paddock on the Heretaunga Plains, Hawke's Bay.

Who: Jamie Thompson (Ravensdown), Chris Zuierwijk (Bostock) and Bruce Searle (Plant & Food Research).

What:

- The data showed a strong linear relationship between the N concentration measured by a TriOS Nico nitrate sensor and in the grab sample. This indicates that the sensor can provide a good indication of sump nitrate-N concentrations, and that with calibration the accuracy can be improved further.
- The ability to measure real-time nitrate concentrations in the drainage water provided data showing clear links between management practices, rainfall events and N leaching.
- Both modelling and real-time data also showed that modified agricultural practices can reduce nitrate losses to groundwater, through reducing the depth of irrigation, applying smaller but more fertiliser applications through the growing season, and using catch crops.

Read more: *Measuring real-time nitrogen losses in vegetable production – part 2*: ourlandandwater.nz/RPF2022

Research showed it was possible to measure and reduce nitrogen (N) loss in real-time from a vegetable production paddock in the Hawke's Bay. How effective would a cover crop be in soaking up excess N from the paddock over winter?

In 2020, grower Chris Zuierwijk planted up a final conventional crop of onions on a 16 ha paddock near Clive on the Hawke's Bay's Heretaunga Plains. When the crop was lifted in January 2021, the paddock would see the end of conventional inputs and synthetic fertilisers.

The conversion from conventional vegetable production to an organic system was being undertaken by Bostock New Zealand. It was an opportunity not to be missed for Ravensdown consultant Jamie Thompson. While it was known rain and irrigation events were having an effect on the mass of nitrates leaching from fertiliser applied to paddocks, knowing how much was being lost and when was important, along with how to reduce these losses.

Hawke's Bay Regional Council is tightening up regulations around crop cultivation in the huge intensive export and process growing area through the introduction of Plan Change 9 (TANK). This includes minimising risks to waterways from nutrient loss, by requiring hundreds of horticultural growers in the area to develop management plans that identify and address these risks.

An initial six-month project to investigate using real-time monitoring to measure N losses from drainage after rainfall and irrigation was undertaken by Jamie in 2020, with funding from the Our Land and Water Rural Professionals Fund.

After the results from the successful trial led to the modification of some good agricultural practices, a small amount of funding from the Rural Professionals Fund was approved to extend the project into 2021. Chris was then able to continue monitoring the paddock for another six months as he put in a winter crop of oats. This crop wouldn't receive any fertiliser and it was intended to see how much soil N it would soak up.

The paddock's story so far

Poorly draining, the paddock had dense clay-rich subsoil sitting about 50 cm below the soil surface, along with a high water table in winter.

Tile-and-mole-drained, all the drains in the paddock lead to a single sump where Jamie installed a TriOS Nico nitrate sensor. This measures nitrate-N concentrations in wells and sumps.

By taking collected samples immediately for lab testing, this showed how accurate the sensor was in real-time, as well as the effects of irrigation and wet weather events on N leaching.

Soil samples were collected when the crop was planted, and when the crop had finished they were sent to Analytical Research Laboratories (ARL) in Napier for analysis (**Table 1**).

After the onions were planted fertiliser was applied four times, about a month apart, with a total of 153 kg of N applied per hectare.

Decagon sensors at the front and back of the field gauged the amount of moisture in the soil every couple of hours at 15, 30 and 60 cm depths, with two flow meters recording weekly drainage.

Hourly readings were taken by the TriOS Nico nitrate sensor in the sump, with a weekly sample taken to ARL and the nitrate concentration measured. Twenty onions from the final crop were taken to ARL to measure their N content.

Sensor results similar to grab samples

There was 113 kg/ha of mineral N in the soil at planting, with 86 kg/ha remaining in the soil (mostly near the surface) when the onions were lifted.

The sump sensor and weekly sampling showed some nitrate leaching whenever it rained, with losses of about 0.16 kg/ha each week. But a big downpour in November, within a week of fertiliser going on, saw a huge spike with 3.7 kg/ha of N lost in a week.

Leaching stayed high, gradually decreasing through to the end of cropping, with a couple more spikes from irrigation, and 9 kgN/ha in total eventually leaching off the paddock (**Figure 1**).

The TriOS Nico nitrate sensor and the grab samples showed similar results, with the sensor showing levels about 8% higher than lab results and a clear link between management practices, rain events and leaching. Calibrating the sensor would give more accurate real-time nitrate losses.

This would enable farmers to decide if they wanted to reduce the depth of each irrigation, use smaller fertiliser applications and increase application numbers through the growing season.

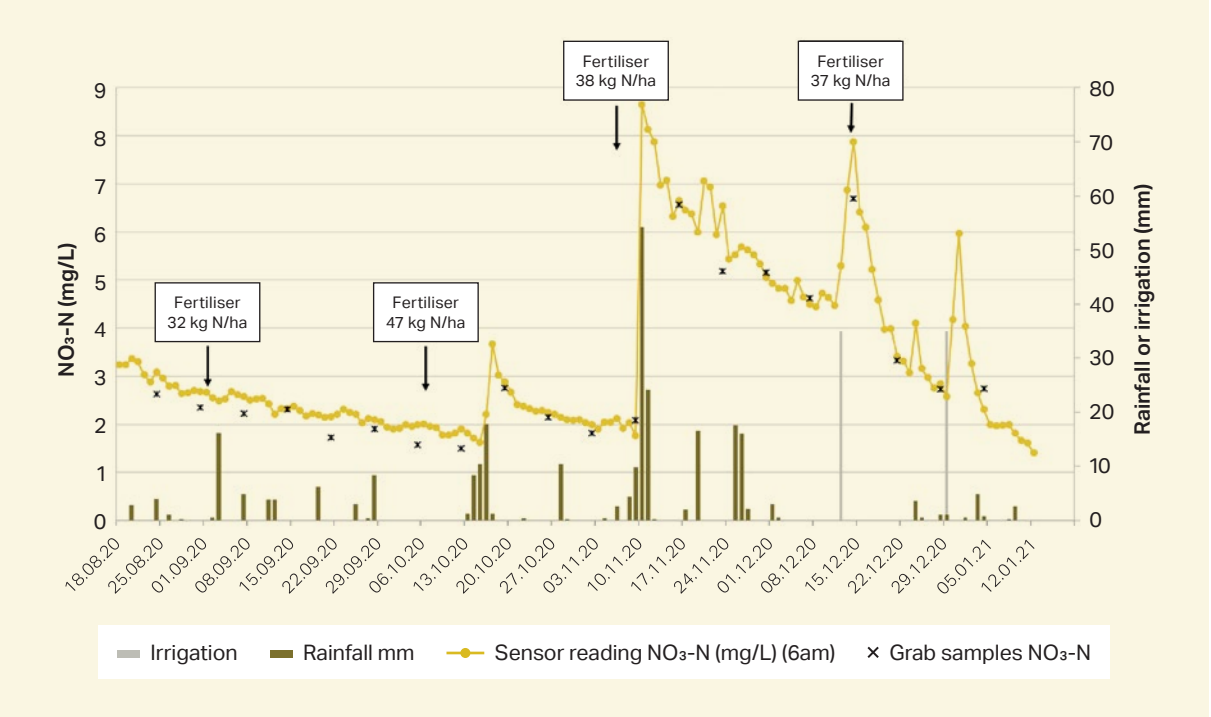

Figure 1: Nitrate concentrations in drainage water relative to rainfall and management events including irrigation

There was 113 kg/ha of mineral N in the soil at planting, with 86 kg/ha remaining in the soil when the onions were lifted.

The potential increase in eCO_2 from running machinery would be a consideration, as it was for this next phase of the project.

Confidence in the TriOS Nico nitrate sensor being accurate saw the second phase of the trial begin.

The story continues

Of the remaining N in the soil after the onion crop was raised, 80% was in the top 30 cm. Data from the sump sensors continued to come in and weekly samples continued to be tested.

N leaching dropped to almost negligible levels once the onions were lifted in January, with no irrigation and no heavy rain until late June. By this time the oats had been in the ground for three months without any fertiliser. They were mulched in early July and turned into the soil three weeks later when the paddock was ploughed. There were two heavy rain events around this time, which saw some leaching but substantially less than before.

OverseerFM was then used to model several scenarios to see what difference there would be to greenhouse gas emissions by leaving the land to lie fallow compared to planting it up in oats.

It found 23 kg/ha leached from the paddock over the year. The oats would have soaked up 18 kg/ha, reducing N leaching to just 5 kg/ha for the year. Greenhouse gases increased with the oats scenario by 25%.

"Because the ground is so waterlogged over winter, turning the oats in would have seen nitrous oxide emissions increase, along with emissions from tractor use," says Jamie. Growers need to carefully consider the effects of trade-offs between nitrate losses and greenhouse gas emissions.

"The project has been very successful," he says. "The results of the initial project saw a lot of interest in the technology and installing sump sensors is now likely to become more standard practice."

Zespri has also shown interest in installing sensors on kiwifruit orchards, with interest also from national agriculture and horticulture consultancy business AgFirst.

Jamie is hopeful that tracking N losses in real-time will raise people's game and lead to improved management practices.

Delwyn Dickey for the Our Land and Water National Science Challenge