Irrigation strategies for reducing nitrous oxide and nitrate leaching.

Production benefits of irrigation are well established. However, intensive irrigated agricultural production can also lead to unintended environmental emissions and leaching losses.

A three year MPI-funded project has recently been completed to identify irrigation strategies to help reduce nitrous oxide emissions and nitrate leaching in pastoral systems without losing production. Results from MPIs Sustainable Land Management and Climate Change (SLMACC) programme have identified ways to achieve win-wins for production and environment.

Nitrous oxide in New Zealand agriculture is mainly produced from animal urine patches, especially when soils are warm, wet and compacted. Because of the high global warming potential of nitrous oxide compared to carbon dioxide, even relatively small emissions of nitrous oxide are important.

Nitrate leaching occurs when soil nitrate is transported below the plant root zone in drainage water. This is usually considered a winter issue because rainfall is often greater than the plant's capacity to use it. However, if soils are kept wet, the risk of drainage increases especially when a rainfall occurs soon after irrigation.

The research was conducted by Plant and Food Research, AgResearch and Landcare Research, and involved field trials in Canterbury and Otago, a lysimeter experiment and additional modelling to test management options. Research was focused on providing practical irrigation management options for reducing greenhouse gas emissions. This included changes in irrigation frequency, modifying irrigation trigger points and application depths, comparing irrigation application intensities and delaying grazing timing to reduce compaction.

Research findings:

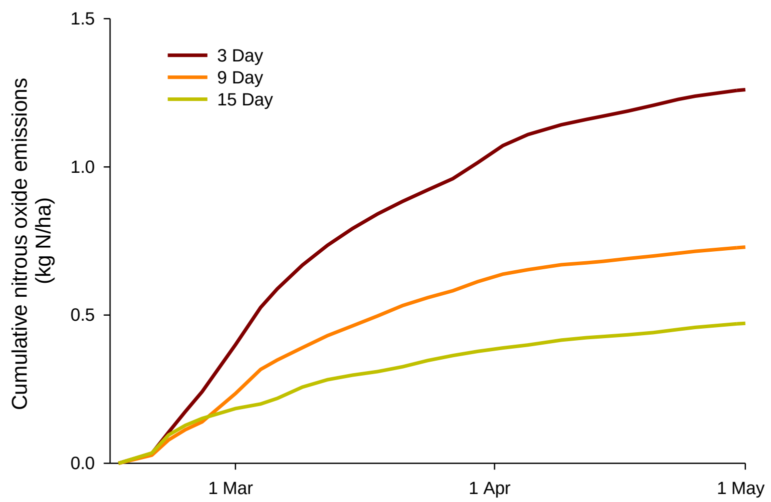

Figure 1 Cumulative nitrous oxide emissions from urine patches on a shallow stony Canterbury soil irrigated at high (every 3 days) to low frequencies (every 15 days).

Field trials showed that more frequent irrigation kept the soil wet increasing nitrous oxide losses (Figure 1). However if the soil was allowed to dry out more over longer irrigation return intervals, these losses could be reduced without penalising pasture production.

Soil type is important. There were large differences in the nitrous oxide emissions from deep, poorly drained soils and shallow, freely drained soils. Nitrous oxide emissions were much greater from the poorly drained soils. This is because the poorly drained soils remained saturated for longer promoting more nitrous oxide production.

> Shallow stony soils have limited water storage potential —"small buckets".
>
> In most cases, modern irrigators have the potential to apply amounts that can still leave the "bucket" partially full, even in a shallow stony soil.
>
> This Eyre soil has about 70 mm of available water in the top 60 cm, or 35 mm of readily available water.
>
> Applying 15 to 20 mm of irrigation and triggering at or about 25 to 35 mm gives plenty of "headroom" to capture rainfall events.

However, because deep soils can hold much more water they also require less irrigation over the season. Early in the season soil water storage delays the need for irrigation. Greater storage also allows these soils to capture more rainfall than the shallow soils. Therefore, irrigating these soils less frequently and letting the pasture use more of the stored soil water reduces nitrous oxide emissions.

Conversely, summer drainage and nitrate leaching from the deep poorly drained soil was less than from the shallow freely drained soil. This is because of the difference in ability of the soils to capture rainfall during the irrigation season.

Avoiding grazing for 6 days after irrigation on a poorly drained soil to allow plants to dry out the soil reduced nitrous oxide emissions by 40% compared to grazing within 2 days of irrigation.

The overall key finding from the research and modelling was that reducing the irrigation frequency by triggering irrigation at lower moisture contents could be achieved without penalising pasture production with the benefit of significantly reducing the risks of leaching, nitrous oxide emissions and soil compaction. Irrigation that brings the soil back to field capacity should be avoided if possible.

There are some caveats. In many cases, irrigation systems will struggle to meet peak plant water use demands in summer, especially on soils with low water holding capacities. During this time, the risk of drainage and nitrous oxide emissions are much lower as plants quickly deplete soil water.

Recommendation

Our recommendation is that farmers should focus on managing “shoulder periods”. This is when most irrigation systems have the capacity to keep up with the plant water demands.

We have put together an information sheet to guide farmers on the benefits of managing soil water deficits. Benefits included a reduction in number of irrigations, saving $s, less drainage losses, less leaching and reduced nitrous oxide emissions.

The information sheet will be available from the MPI Climate Cloud website (www.climatecloud.co.nz)

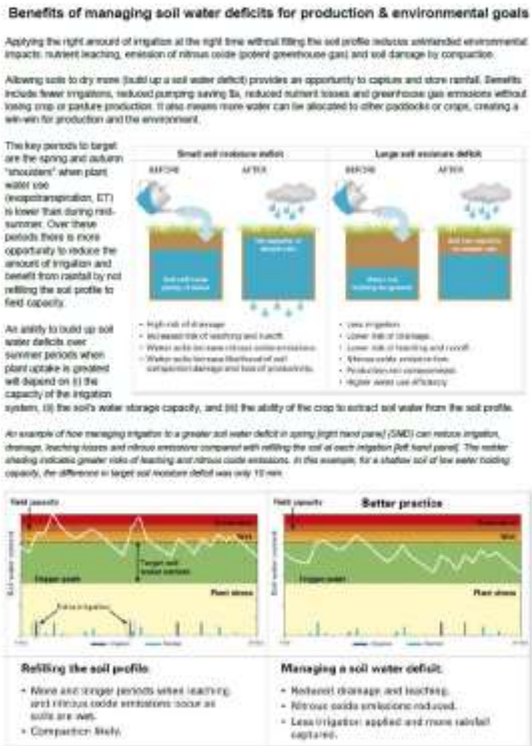

Figure 2 Information sheet on benefits of managing soils water deficits.

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