Process Vegetables NZ

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Lysimeters... Improving estimates of drainage and leaching

IN BRIEF

Tools to assist farmers

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Plant & Food Research

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2015
International Year of Soils

The PVNZ (Process Vegetables New Zealand) Board held its Research and Development meeting in March 2015 at Lincoln, Canterbury, and visited Plant & Food Research to follow up on the progress of several research projects being undertaken on behalf of the PVNZ R & D board and respective levy payers.

The first project being managed by Dr Trish Fraser, a senior soil scientist at Plant & Food Research, provided an excellent overview on the use of lysimeters to understand and monitor water and nutrient flows.

Computer models are now commonly used as agricultural management tools to assist farmers, growers and their advisers to examine nutrient use and movements within farms and orchards to optimise production and environmental outcomes. Such models can calculate and estimate the nutrient flows in a productive farming system and identify risk for environmental impacts through nutrient loss, including run-off and leaching, as well as greenhouse gas emissions.

To construct the models in the first place though, there needs to be some basic knowledge of the many underlying relationships between the different parts of the system. For example, how different plants are likely to interact with different soils at different times of year, under different climatic conditions and when variable amounts of water and/or nutrients are available for plant growth. How grazing animals will influence both the plants and the soil, so that our models can allow for their impacts. Also how other management practices such as irrigation or cultivation might affect our soils, because these will also influence soil nutrient availability and plant productivity. To answer such questions and improve our understanding, a huge amount of underpinning research has been (and continues to be) conducted around New Zealand. Although every combination cannot be measured, the relatively recent advent of agricultural systems models has enabled us to measure outcomes under a wider range of conditions, to provide increased insight into how agricultural systems work as a whole.

Understanding this has already markedly improved through the use of computer models. But to validate

Figure 1 The lysimeter barrels placed into the trench at the new facility, showing cabling attached to sensors within the soil profile. Drainage is collected via a tube leading from the base to a collection vessel for later analysis.

Figure 2 A lysimeter experiment in progress. Note collection boxes in the walkway where leachate is collected via a tube from the base. Irrigation can be applied and the grass being grown in each lysimeter is also grown in the surrounding soil to further create similarity to the whole paddock environment. The retractable rain-shelter is in the background.

these model predictions, we also still must have real measured data against which we can test the model's assumptions. There are some areas where data is still limited, yet needed to test model accuracy and ultimately improve the accuracy of predictions.

One area scientists at Plant & Food Research (PFR) are trying to refine is the predictions of drainage and leaching losses from soil under on-farm conditions. There are presently few actual drainage measurements available to test and refine models, so to date it has essentially just been assumed that any water that enters and is not evaporated from the soil surface or taken up by plants will be retained within the soil profile. But where too much water enters the soil (depending on how much the soil can hold), it is assumed that the water will drain. >

To test whether these assumptions are sufficiently robust and to refine estimates of drainage and leaching losses, we need to gather more data to further investigate the underlying mechanisms regulating these processes, and to quantify more reliably all the inputs and outputs of water and nutrients to and from different soil types under known conditions. This data can be best and most reliably obtained from controlled lysimeter experiments.

BUT WHAT ARE LYSIMETERS?

A lysimeter is a term used to describe a large undisturbed, encased block of soil, used to conduct experiments where all the inputs to the system can be controlled and the outputs reliably measured. Commonly in New Zealand, lysimeters are constructed using large barrel-like, metal, cylinder casings (Figure 1 and Diagram 1). The metal casings are placed on top of the soil. Soil around the outside of the casing is then removed manually (approximately one spade depth at a time) to expose a soil pillar with a slightly greater diameter than the casing. The lysimeter casing is gently pushed over the exposed soil pillar, and the excess soil shaves off as the cylinder is lowered. The process is repeated until the soil fills the casing. The soil contained inside the lysimeter is both physically and chemically unchanged except around the outer fringes of the cylinder. To prevent water or nutrients from travelling preferentially between the soil and the metal casing, we commonly inject in molten Vaseline, which when it cools, forms a watertight seal around the outer edge of the soil from top to bottom of the casing. The lysimeter is then detached from the underlying soil by driving a plate slowly under the base of the casing, using a hydraulic ram. It can either remain at the sampling site, or be transported to a specially designed facility. In such a facility controlled-input, replicated experiments can be carried out.

Figure 3
Methven – Lismore stony silt loam.
Average annual rainfall = 960mm.

Lincoln – Eyre soil.
Average annual rainfall = 650mm.

Overall, the work involved in extracting the lysimeters is very difficult and this is why lysimetry is very costly to research.

Recognising the importance of this work, PFR has recently significantly invested (just short of $200,000) in construction of a new facility at their Lincoln site, to house up to 52 lysimeters (each 50cm diameter by 70cm deep). The facility is slightly different from others already operational in New Zealand, in that it also sports a retractable mobile rain-shelter to cover the lysimeters when it rains. This allows all water inputs to be strictly controlled whilst still exposing the lysimeters to natural outdoor environmental conditions (e.g. temperature and sunlight). It also enables researchers to vary the amounts, intensities and/or timings of water application accurately, to better understand how irrigation affects water and nutrient movement through different soil types.

Lysimeters can be collected from a range of locations with different soil types, allowing for side-by-side comparisons under similar, but controlled, environmental conditions. For example, the facility at present houses one set of lysimeters from a site near Methven with Lismore stony soils, and another set from a site with Eyre soils near Lincoln. There are stark differences in the colour and distribution of gravels between the two soil types (see photographs). The colour difference is in part due to these Lismore soils originating from much nearer the mountains, where they annually receive considerably more natural rainfall. Over time, more of the organic material in the soil is leached through the soil profile. We have more to learn about how water moves through such differing soil profiles under different irrigation regimes; how well and from what depths different plant roots can extract or retrieve nutrients from within the different soils; and overall, what proportion of nutrients is ultimately lost from the system. Nutrients like nitrogen (commonly applied as a fertiliser or returned to soil as a component of urine) can be lost via leaching or by gaseous emissions.

The types of experiments that can be conducted using lysimeters are many and varied. Essentially we can track the fate of any material that is applied to the soil surface: for example, water (rainfall or irrigation), fertiliser, animal dung or urine, dairy effluent, herbicides and pesticides or even faecal coliforms. There are special techniques to "label" the materials applied to the lysimeter soil surface, to identify where they end up. And we can also grow different plant species on the lysimeters – e.g. cereals, forages or vegetables as well as pasture.

The advantage of lysimeters, however, is that for most purposes they can be considered closed systems, since we can:

- Measure what materials are taken up by the plants, by periodically harvesting and analysing the plant material.
- Place special covers over the top of the lysimeters to assess any losses via gaseous emissions.
- Put drainage systems in place to collect, sample and analyse any water that flows out of the base of each lysimeter *(see Diagram 1)*.

The first two experiments have recently been completed using the new facility. In one, cattle urine was applied (which contained approximately 600kg N/ha) to half the lysimeters and the impact of three different rates of irrigation on the amount of nitrogen that was leached following a urination event was investigated. Results are still being analysed from this work, but one interesting observation over the nine-month experiment was that significantly less water drained out of the lysimeters to which urine had been applied than from those where no urine was applied. This of course was due to the pasture plants responding to the nitrogen in the urine, growing more rapidly, and consequently using more water, so the whole paddock cannot be treated as equal – the areas that receive urine behave quite differently from the rest of the paddock.Research findings will be used by the model makers, who use the data to test the models, tweek their parameters, and further improve the accuracy of their predictions of drainage and leaching. G

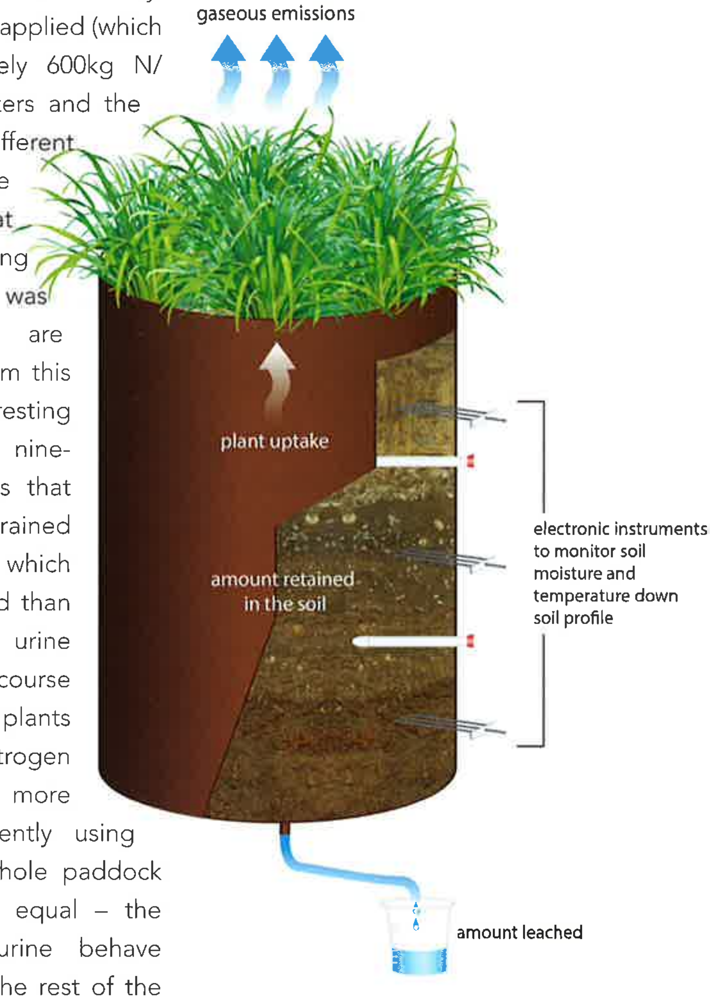

Diagram 1 Measuring the fate of the materials applied to lysimeters.