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Sustainable Vegetable Systems: quarterly report October–December 2022

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Summary

Workstream 1: Field experiments

- Ryegrass seed crops in Rotation 1 and 2 (Lincoln) have been harvested. These fields have been left in pasture after the seed harvest.
- Data continues to be collected for the ryegrass hay crop in Rotation 3.
- A sequential harvest plan was implemented for the cauliflower harvest, to meet commercial standards. Advice on commercial quality of cauliflower curds for harvesting was provided by the commercial grower and agronomist.
- Data continue to be gathered and analysed as planned.

Workstream 2

- We have continued to process samples for biomass and crop nitrogen (N) content.

Workstream 3

- A significant amount of work has gone into coding and preparing a grower-facing tool.
- Options for managing intellectual property (IP) have been implemented.

Workstream 4

- Planning continues for a Sustainable Vegetable Systems (SVS) roadshow in 2023.
- A conference paper was presented to the New Zealand Society of Soil Science Conference in Blenheim in November 2022.

1 Workstream activity

Activity this quarter focused on:

- Collecting data in Workstream 1.
- Preparing and coding the grower-facing tool in Workstream 3, as well as further improving the modelling process.

1.1 Workstream 1: Field experiments

Our focus was on collecting crop, soil and leaching data for the ryegrass crops in Rotations 1, 2 and 3, and the cauliflower crop in Rotation 4 (Figure 1). These rotations are implemented at the New Zealand Institute for Plant and Food Research Limited (PFR) farms at Lincoln, Canterbury and Havelock North, Hawke's Bay.

Crops have four treatments of nitrogen fertiliser: a control of no fertiliser (N1), an amount that tends to be limiting to growth (N2), an amount that does not limit growth (N3), and an oversupply of nitrogen (N4). These rates help to develop an understanding of soil and crop responses to N needed for the modelling process. There are also two irrigation treatments: I1 is considered an optimal irrigation supply that does not limit yield. The I2 treatment provides a little more irrigation to bring the soil water content closer to field capacity. This is to provide greater opportunities for drainage when rainfall occurs and hence for leaching, which is an important component of understanding the nitrogen movement in the soil-crop system.

The data on crop nitrogen content and soil nitrogen are still being processed and analysed, and these data will be discussed in subsequent reports.

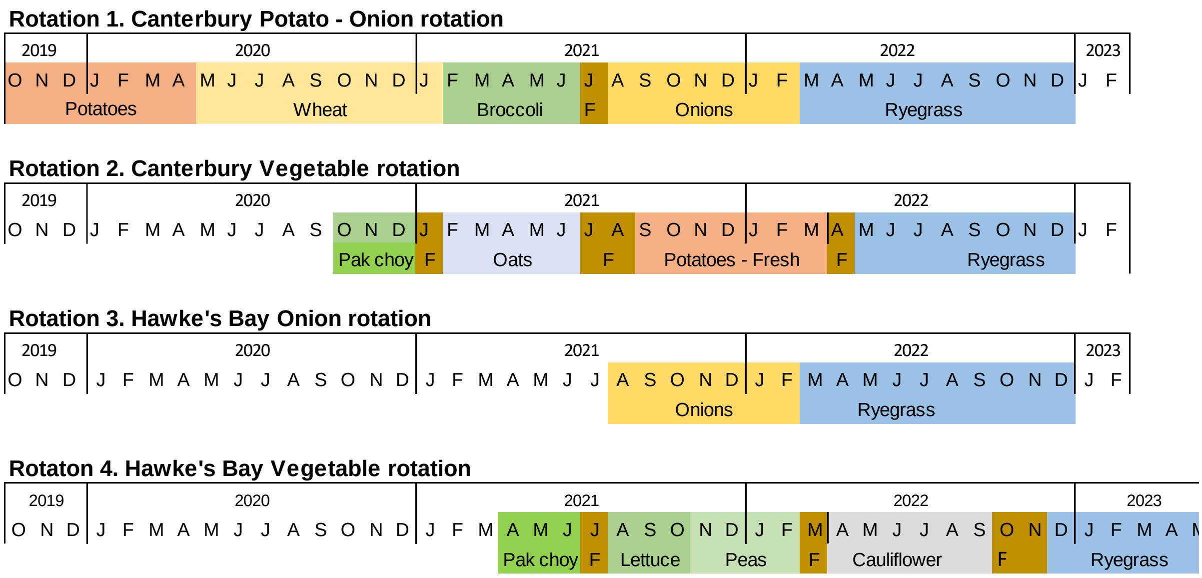

Figure 1. The four vegetable crop rotations implemented at PFR research sites in Canterbury (Lincoln) and Hawke's Bay (Havelock North).

1.1.1 Canterbury rotations 1 and 2

- Focus has been on growing the ryegrass seed crops sown on 6 May 2022 and collecting plant and soil data (Figure 2). These data are currently being analysed for N content. After the seed harvest, these ryegrass crops will be left in the field.
- During this quarter irrigation needed to be applied. A total of 165 mm was applied to the good management irrigation treatment (Irrigation 1; replacing soil moisture lost through evapotranspiration). For Irrigation 2 treatment (an additional application to field capacity to facilitate leaching), a total of 215 mm was applied. However, no drainage events causing leaching occurred during this period. There was a total of 138.6 mm rainfall during the October–December 2022 period, and only one rainfall event was large (20.4 mm on 19 November).

Figure 2. 'Nui' ryegrass seed crops in Rotations 1 and 2 grown at the PFR research farm at Lincoln, Canterbury.

- Some N was applied at planting at the rate of 0, 15, 30 and 60 kg N/ha to N1, N2, N3 and N4 plots, respectively. This was to ensure a good crop establishment going into winter. Please note, 29 kg N/ha were applied to all plots in Rotation 1 due to a contractor's mistake.
- For the N3 good management treatment, the required amount of N for an established crop (closed rows) was estimated at 172 kg N/ha (FAR 2013). The supply of N from the soil included 15 kg N/ha from the mineral N pool and 66 kg N/ha produced over the growth period from soil mineralisation. We used measurements of soil mineral N at monthly intervals and monthly estimates of N mineralisation to estimate the side-dress rates of N fertiliser. The first two side dressings (1 September and 29 September 2022 respectively) were 40 and 30 kg N/ha. Based on likely mineralisation to be produced in the October to December period, we estimated that ~20 kg N/ha needed to be applied to meet requirements for best management production.

- This gave the third side-dressing rates of 0, 10, 20 and 40 kg N/ha with total N applied of 0, 60, 120 and 240 kg N/ha for treatments N1, N2, N3 and N4, respectively. Differences in N treatments were visible (Figure 3.).

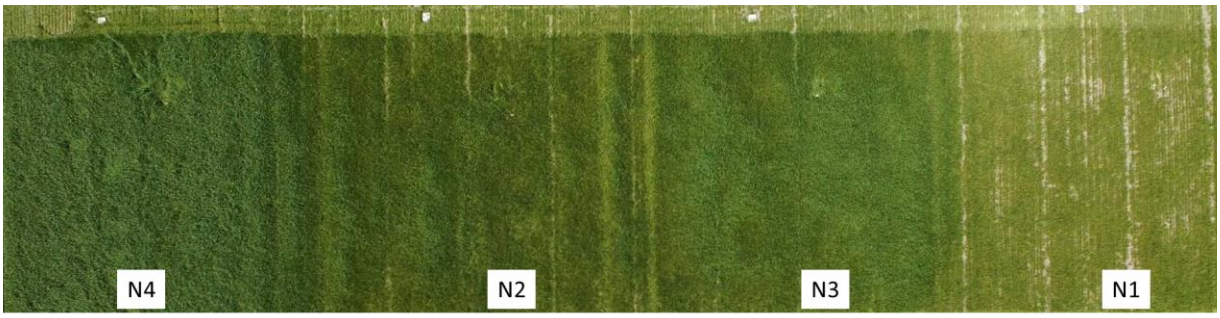

Figure 3. Nitrogen treatments of ryegrass crops from Rotation 1, grown at the PFR research farm Lincoln, Canterbury. Image taken 11 November 2022. Total N application rates are 0, 45, 90 and 180 kg N/ha for treatments N1, N2, N3 and N4, respectively.

1.1.2 Hawke's Bay rotation 3: Onion rotation

- A catch-crop of 'Asset' and 'Tama' ryegrass, a common mix as grazing or a silage/hay crop, was sown at a rate of 25 kg/ha on May 20, 2022. The crop is well established (Figure 4) and our focus this quarter has been collecting soil and crop data from this crop and managing production. Plant and soil samples are being analysed for nitrogen content in the laboratory.
- We have treated this as a catch crop and no N fertiliser has been applied.

Figure 4. Ryegrass crop consisting of a 50;50 mix of 'Asset' and 'Tama' ryegrass' grown as hay at the PFR Hawke's Bay research farm.

- Rainfall was high in the October to December 2022 quarter, with a total rainfall of 201 mm. From sowing until the end of September there was 461 mm. This gives a total rainfall of 662 mm during the growth of this crop. Because of the rainfall, no irrigation has been applied to this crop.
- Leachate samples have been collected a total of 10 times for this crop, owing to the heavy rainfall (Figure 5).

Figure 5. Collection of leachate samples from the ryegrass crop in Hawkes's Bay. Clockwise from top left figure: placing vacuum on suction cups at 60 cm and 120 cm soil depth to extract soil solution. Vacuum is placed on the suction cups for 1 hour. Tubes are identified depending on depth and prepared to release suction. After suction is released solution flows into the collecting vials. The last image shows the vials with soil solution samples. Vials are then sealed and frozen until laboratory analysis can be completed.

1.1.3 Hawke’s Bay rotation 4: Vegetable rotation

- The final harvest of the cauliflower crop of variety ‘Caspar’ started on 10 October, 151 days after transplanting (12 May 22). Plants that were of commercial size and quality were harvested every second day, with the last plants reaching commercial size and quality being harvested on 4 November, so that the sequential harvesting period was just over 3 weeks long. The final harvest of commercial cauliflower curds used input and advice from a local commercial grower and agronomist. Data are being collated and analysis of crop and soil N content is being carried out.
- During growth of this crop there were a total of 10 leachate collections. Seven of these were in the July–September quarter when there was a total of 372 mmm of rain, and three in the October–December quarter, when there was 201 mm of rain.

- Following the cauliflower harvest, a crop of 'Winter Star II' ryegrass was sown for a hay crop on 13 December 2022.

1.2 Workstream 2: Regional monitoring

- Data have continued to be collected on the regional farms by the regional monitors. The biomass data have been processed by PFR and samples are at the lab for completion of N content analysis.
- Data are being collated and passed onto Workstream 3.

1.3 Workstream 3: Modelling

Model design and implementation

Workstream 3 centres on modelling, decision-support tools like Overseer or APSIM and their calibration and validation. This Workstream aims to provide a tool or suite of tools to help growers implement good management practices and to provide assurance to regulators. This Workstream utilises data gathered in Workstream 1 and 2. Data from each trial site are being used to run modelling simulations, establish target N leaching and compare observed and modelled data to inform further research, validate and/or develop models. This Workstream reviews current tools, and is developing a tool for potato and vegetable crop production and compliance for different land-use practices.

This Workstream will provide regulatory bodies with tools and data to manage environmental impacts. This will either improve the accuracy of modelling tools for crop farming or provide an effective alternative. Conversely, the output of this Workstream will be used by growers and industry to manage their on-farm practices.

- The work happening in Workstream 3 (WS3) is shown in Figure 6.
- Data from Workstream 1 (WS1) and 2 (WS2) are used in the modelling. WS1 data are used to improve APSIM yield and drainage predictions. These data in turn provide finalised data that are used for developing the grower-facing tool (GFT).
- The WS1 data also help improve the APSIM tool for evaluation of mitigation options.
- WS2 data provide finalised data that contribute to testing the GFT. The GFT is a tool that provides information for proactive on-farm management of nitrogen fertiliser. By using an approach that minimises the N balance while ensuring yield is not limited, compliance can be demonstrated.

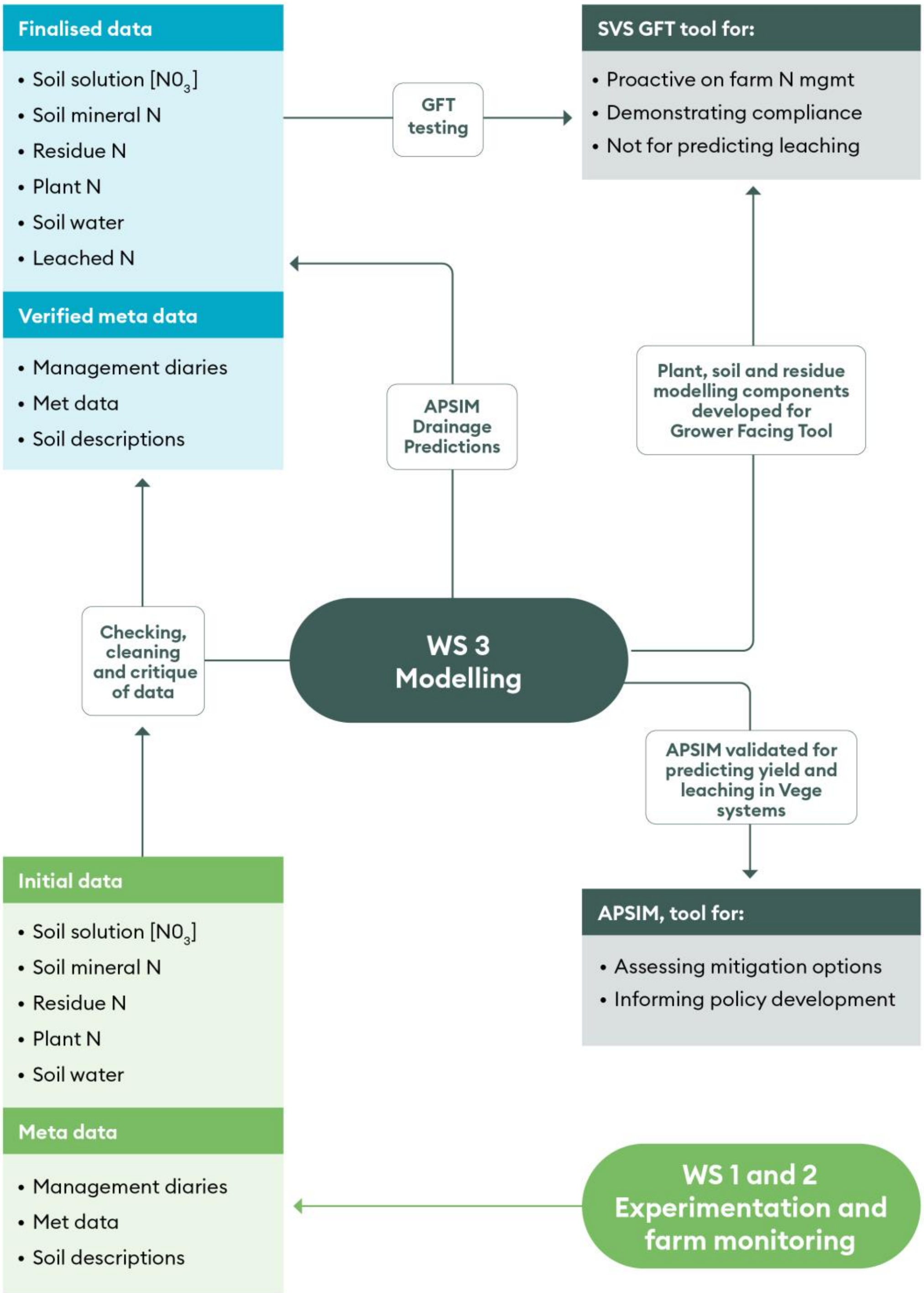

Figure 6. Modelling activities within Workstream 3.

Coding to develop the GFT has been underway, and has helped to address IP issues:

- A first prototype tool was developed with a Dash-based interface and a code base programmed in Python language. This utilised components of the improved crop model developed for Overseer (with permission from Overseer). It was very useful for demonstrating the concepts of how a N balance tool would look and could be used, but it could not be distributed because of IP constraints and the cost associated with broad distribution using Dash.

- Options for sharing IP with Overseer have been investigated, but we have concluded it would be too restrictive for developing the SVS GFT in the timeframes and budgets available.

- Instead, PFR have written a N balance model in the C# language, based on the ideas in the first prototype but with the code written from scratch. This is now a clean piece of IP which SVS has full freedom to use and evolve as most fit for the delivery of the SVS tool.

- The development of the SVS tool will require parallel development of user interfaces, collation of model coefficients and refinement of model code. To facilitate this the C# code has been written in a modular fashion so different interfaces can call the same code, and different sections of the model can be updated without affecting interface development and testing.

- A second prototype has been developed with an MS Excel® interface passing information to and receiving results from the C# code, which are then summarised in Excel. This prototype will be used for testing and early end-user engagement for case studies.

- Planning is also under way for the final interface which will be a web-based delivery of the tool developed by Rezere.

- Outstanding jobs to do for model development (not including interface development) are the inclusion of the HWEON test method for predicting soil organic matter mineralisation, the inclusion of a model for predicting residue mineralisation, and the completion of the table of crop-specific coefficients.

- It was a major challenge to rewrite the N balance model in C# as it deals with structured and typed data in completely different ways from Python. However, this investment should be worthwhile as it now means we have full freedom to operate (FTO) with our code base and it is in a language that interfaces with web app development much better.

Model development

- The data from Workstream 1 crops completed have been collated for analysis using APSIM-SCRUM. This is a necessary step for development of the farmer-facing tool.

1.4 Workstream 4: Technology transfer

- Planning for SVS roadshows for 2023, to increase awareness and information sharing, was continued.
- A conference paper was presented to the New Zealand Society of Soil Science Conference in Blenheim in November 2022:

  Fraser P; Searle B and Brown H, Michel A, Barber A. 2022. Improving our understanding of nitrate leaching from vegetable cropping rotations. Presentation at "Soil - Aotearoa's most precious resource - past, present, future". NZ Society of Soil Science Conference, Blenheim 28 November-1 December 2022.

2 Key highlights and achievements

Workstream 1

- Ryegrass seed crops in Rotations 1 and 2 (Lincoln) have been harvested. These fields have been left in pasture after the seed harvest.
- Data continue to be collected for the ryegrass hay crop in Rotation 3 (Hawke's Bay).
- A sequential harvest plan was implemented for the cauliflower harvest, to meet commercial standards (Rotation 4, Hawke's Bay). Advice on commercial quality of cauliflower curds for harvesting was provided by a commercial grower and agronomist.
- Data continue to be gathered and analysed as planned.

Workstream 2

- We have continued to process samples for biomass and crop N content.

Workstream 3

- A significant amount of work has gone into coding and preparing a grower-facing tool.
- Options for managing IP have been implemented.

Workstream 4

- Planning continues for a SVS roadshow in 2023.
- A conference paper was presented to the New Zealand Society of Soil Science Conference in Blenheim in November 2022.

3 Collaboration with other programmes

- Real time N-losses – Rural Professional Fund through the National Science Challenge, Our Land and Water, looking at real-time measurement of N losses under vegetable (onion) production in Hawke's Bay. PFR is providing data analysis support.
- Residue incubation – PFR-funded project looking to quantify the rate of decomposition of different vegetable residues and the rate of N release from the residues into the soil. Some residues were obtained from crops in Workstreams 1 and 2. A scientific journal paper is almost ready for submission that incorporates the results of this work.
- Process Vegetable Coefficients – Process Vegetables New Zealand-funded project quantifying some of the coefficients needed for N uptake and use by processed vegetable crops within Overseer.
- Mineralisable N to improve management – a Sustainable Food and Fibre Futures (SFFF) project looking to improve the measurement and prediction of the amount of biologically mineralised N in a field. This pool of N is a key component for understanding crop N requirements, alongside measurements of mineral N (nitrate and ammonium). PFR leads this project, which includes the Vegetable Research & Innovation Board and Potatoes New Zealand.
- Asparagus N budgeting (Our Land and Water National Science Challenge) – LandWise project looking to quantify N budgets for asparagus crops. This project is using many of the same measurements as SVS of soil N and crop N uptake, and a similar outcome is being produced. PFR has an advisory role in this project.
- Regenerative Management of NZ Vegetables (SFFF) – this project with LeaderBrand is evaluating the use of compost for vegetable production. There is interest in collaboration to ensure a grower-facing tool can incorporate compost as a N source.

4 Upcoming

- Ryegrass (Rotation 3) to be harvested, and ryegrass for hay sown in Rotation 4 after the cauliflower harvest.
- Statistical analyses of outcomes in individual crops and across the rotation will continue.
- N balance discussions and development will be ongoing, and data from Workstream 1 and 2 further evaluated for N balance development.
- Model development ongoing. Scenario testing of data ongoing; including incorporation of Workstream 2 data.

5 Acknowledgements

The growing of crops in Workstream 1 relies heavily on the input of industry agronomists and growers for advice in terms of management, in particular the timing and types of different agrichemicals to be applied for crop protection and producing high-quality product. We have also had excellent support from agronomists and growers around the commercial harvest of the cauliflower, which has helped to ensure good planning and outcome. A big thank-you to the Regional Monitors in Workstream 2, who collect arguably the most representative data of current practice, which are key to the outcome of this work. Thanks to Elysia Arnold for putting our thoughts on Workstream 3 into an elegant and understandable diagram. And finally, a huge thanks to the field team who collect large amounts of data, often physically demanding, and the lab team who work tirelessly to analyse the countless samples collected.

6 References

FAR 2013. Cropping Strategies - Nitrogen in Perennial Ryegrass Seed Crops.

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PUBLICATION DATA

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