APRIL 2019

EXPLORING THE APPLICATION OF PRECISION AGRICULTURE IN CELERY, LEEK AND BABY LEAF PRODUCTION SYSTEMS

KOO WEE RUP DEMONSTRATION SITE CASE STUDY

Adam Schreurs, Schreurs & Sons; Stuart Grigg, Stuart Grigg Ag-Hort Consulting; Carl Larsen, RMCG

KEY MESSAGES

- ✔ **Gridded and pre-plant soil testing allowed more detailed understanding of where nutrients are available to the plant**
- ✔ **Development of a nutrition program and variable rate spreading enabled precise nutrition application across smaller areas**
- ✔ **Drainage and crop health monitoring using drones meant problem areas could be identified and managed early before they impacted yield and the bottom line**
- ✔ **Plant tissue testing provided a useful cross-check to see what nutrients the plant had taken up and whether this varied across a paddock**
- ✔ **Installation and use of remote monitoring insect traps provided another 'safety net' cross-check for manual scouting. Placement lower in the crop is more effective**
- ✔ **Yield assessment showed higher average celery heart weights and more uniformity across the trial block.**

THE DEMO SITE

Schreurs & Sons and the Soil Wealth ICP team have partnered to explore the application of precision agriculture in celery, leek and baby leaf production systems. The demonstration site is located at Adam's Cora Lynn farm, about 80km south-east of Melbourne (Figure 1).

We're aiming to improve nutrition, irrigation and drainage management, and insect pest and beneficial monitoring as a basis for soil and crop health. To achieve this, we've used technology like EM38 mapping, gridded soil sampling, variable rate fertiliser spreading, remote monitoring insect pest and beneficial identification traps with cameras, as well as drones.

This project has been funded by Hort Innovation using the vegetable research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

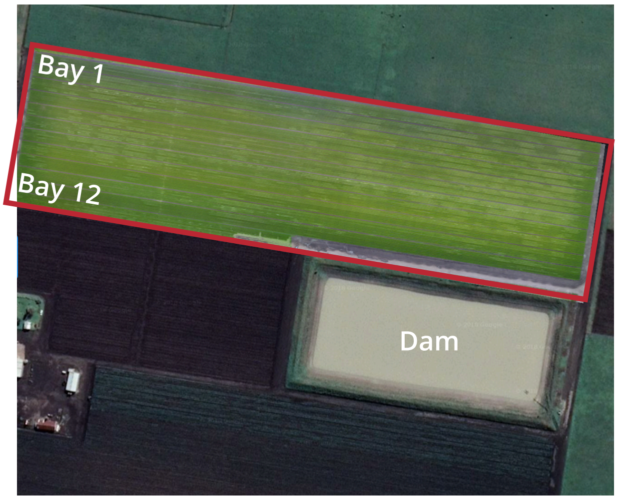

Figure 1: Aerial image of the demonstration site showing the celery crop nearing harvest in January 2019

Further details on the demo site are provided in the table below.

Table 1: Demonstration site details

Component	Details
Area	10.1 ha (25 acres)
Preceding cover crop	Rye grass
Cover crop termination date	Mid-September 2018
Cash crop	Celery
Planting date	Mid-November 2018
Plant density	64,500 plants/ha
Harvest date	Late January 2019
Following cash crop	Baby spinach (1/3) and leeks (2/3)
Trial block location	Bays 1-12
Control location	Bays 30-42

The soil type on the farm is generally a black clay-loam with a topsoil depth of approximately 300-400 mm. Areas of the demonstration site suffer from poor drainage likely due to poor soil structure and nutritional issues (pH and sodium), particularly in the northern parts of the trial block (Figure 2).

Figure 2: Soil profile in the trial block showing the variation between the heavier clay-loam in the north (left) and lighter loam-sand in the south (right) in September 2018

A BRIEF HISTORY

The Schreurs family have been farming on the Koo Wee Rup swamp in Gippsland, Victoria since 1963. Joe and Johanna Schreurs started the family farm and now Adam and Chris run Schreurs & Sons producing celery, leeks and baby leaf.

These crops allow for intensive summer and winter production. This is good for the business but has challenges for managing soil conditions, especially when the need to supply a market and continue production does not allow for breaks in production or for different rotations.

Adam knows that his soil structure comes off second best when mixing heavy harvesting equipment with wet soil during winter leek harvesting. But, when supply deadlines are looming and his crops need to come out, he sometimes has to go onto paddocks when the soil is wetter than he likes.

The need to meet market demands, along with a tight rotation has made its mark on the soil. Adam has noticed a decline in the soil's condition, resulting in increased water logging and greater weed and disease pressure. With the purchase of new land he saw the opportunity to extend his rotation and try something new. Adam thought it would be helpful to continue his collaboration with the project team under the Phase 2 project and trial some new approaches.

WHAT WE DID

Adam, his agronomist, Stuart Grigg, and demo site coordinator from the Soil Wealth ICP team, Carl Larsen, have been busy planning and implementing the trial at the site over the past 12-months.

- The activities have included:
- Gridded and pre-plant soil testing
- Development of a nutrition program and variable rate spreading
- Monitoring of drainage and crop health using drones
- Plant tissue testing
- Installation and use of remote monitoring insect traps
- Yield assessment.

The results and analysis from each of these activities is discussed in more detail below.

WHAT WE FOUND

Gridded and pre-plant soil testing

Soil analysis provides information about potential nutrient availability. Understanding the variability in soil chemistry across a paddock is important for informing the right vegetable nutrition program.

A number of individual soil samples were taken at 36 points in a representative grid across the trial block, as shown in the sample plan in Figure 3. This allowed the team to understand the variability in pH, P, K, Ca, Mg, Na, and CEC at differing depths of 0-20cm and 20-40cm (total and exchangeable %) – a much greater level of detail than a standard 'block-wide' aggregated soil test. Micronutrients of B, Cu, Fe, Mn and Zn were also tested.

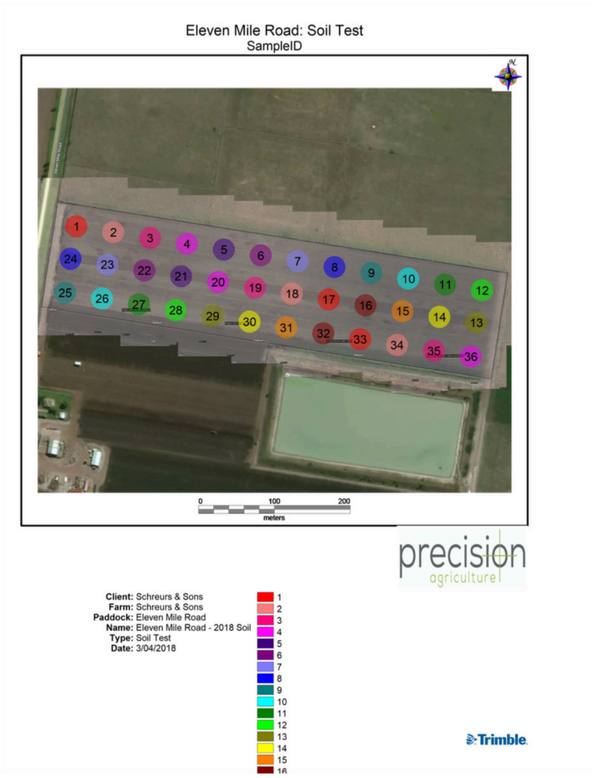

Figure 3: Gridded soil sampling undertaken in April 2018

The output of the gridded sampling for two key parameters, pH and K, are shown in Figure 4 below. This shows large parts of the northern area have lower pH (5.2-5.7 [CaCl2]) and higher K (250-399 mg/kg) compared to other areas of the trial block. This information helped Adam develop a nutrition program for the site.

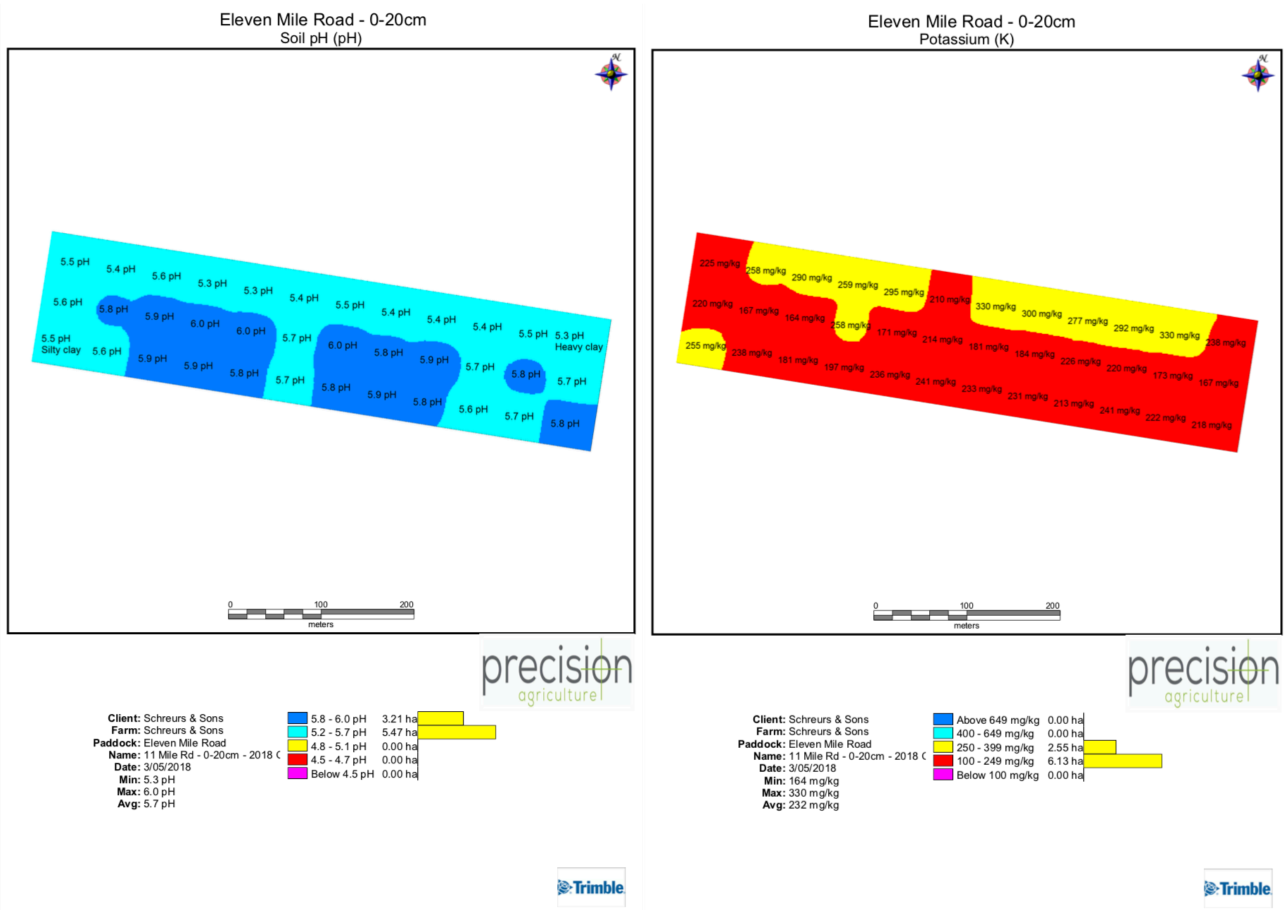

Figure 4: Variability in pH (left) and potassium (right) at 0-20cm identified through the gridded soil sampling in May 2018.

Pre-plant soil pathogen testing was also undertaken to better understand the risk of soilborne disease. This showed an overall low disease risk of planting to a celery cash crop (Table 2).

Sclerotinia spp. are the most important pathogen of celery causing the leaves and petioles of plants to rapidly wilt and die following infection. Luckily, these were found at low levels in both the trial and control blocks. Pythium spp. were also detected in moderate-high levels in some areas and while this infects celery, symptoms may not be observed even if infected.

Table 2: Pre-plant soil pathogen testing results

Species	Trial block	Control
Pythium sulcatum	Low-moderate (4 kDNA copies/g soil)	Low-moderate (3 kDNA copies/g soil)
Sclerotinia sclerotiorum/minor	Low (3 kDNA copies/g soil)	Low-moderate (20 kDNA copies/g soil)
Rhizoctonia solani AG2.1	Moderate (101 pgDNA/g soil)	Low (2 pgDNA/g soil)
Phytophthora[1]	Low	Moderate-high
Pythium Clade F (multiple species)	Moderate-high (599 pgDNA/g soil)	Moderate-high (1246 pgDNA/g soil)
Pythium Clade I (multiple species)	Moderate-high (298 pgDNA/g soil)	Moderate-high (344 pgDNA/g soil)

[1] Detected in both samples using the eucalyptus cotyledon bait test. Phytophthora was identified by hyphae morphology and confirmed by a CSL spot test. Test was not quantitative.

Development of a nutrition program and variable rate spreading

Developing a nutrition program is important for guiding what nutrients are applied, where, when, and at what rate. The results of the gridded soil sampling provided valuable information for development of the nutrition program for the site. This was developed by the demo site agronomist in collaboration with nutrition experts.

Once the nutrition program was developed, variable rate spreading was undertaken on the trial block during October 2018 (Figure 5). Variable rate allows fertiliser to be applied at different rates depending on the changes in soil chemistry across the block. The aim is to achieve a more consistent and high-quality cash crop through more precise application of nutrients.

The spreader maps for two key inputs, SOP (sulfate of potash) and lime, are provided in Figure 6 below. This shows SOP rates varied from 0kg/ha in isolated areas in the north to a massive 500kg/ha in two banded strips in Bays 5 and 7. Similarly, lime rates varied from 0kg/ha in areas where there was optimal pH to over 11kg/ha in problematic spots in the north of the block. A huge difference in inputs – and costs – for a relatively small block for Adam.

Figure 5: The variable rate spreader being loaded (left) and the in-paddock result (right) during October 2018

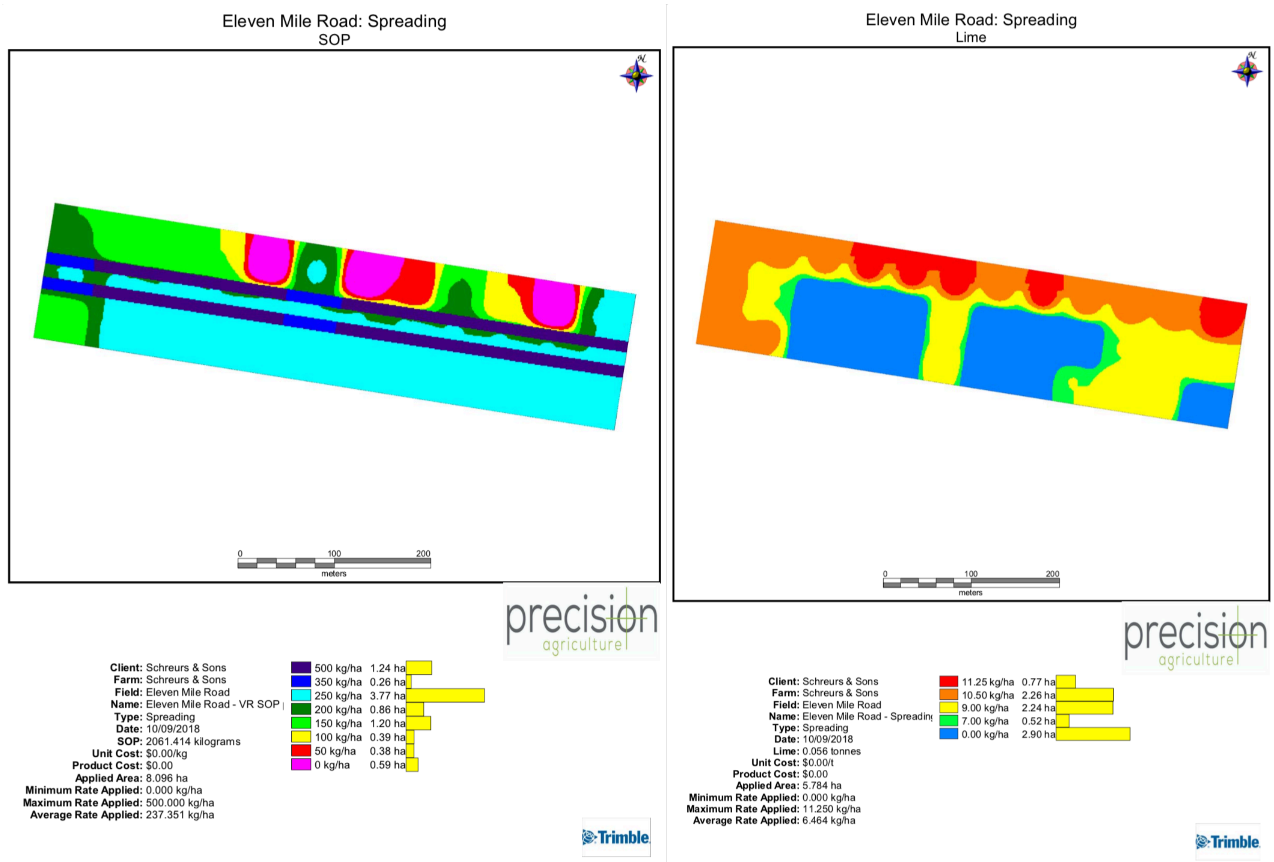

Figure 6: Variable rate application rates for SOP pass 1 (left) and lime (right) in October 2018

Drainage and crop health monitoring using drones

Drones are playing an increasingly important role in providing growers and advisors with real-time imagery and data to make better farm management decisions. We chose to use a drone at the site to monitor problem drainage areas, particularly in the northern parts of the block, as well as track crop growth and health using NDVI (Normalised Difference Vegetation Index) imagery.

The problem drainage areas were monitored using a drone at key development stages of the crop. Figure 7 shows the low areas with water laying in furrows clustered in the north-west corner and central-southern parts of the block, which is where the crop had historically not performed as well. With a greater understanding of the drainage problems, Adam was able to more closely monitor irrigation in these areas to avoid excess water and waterlogging.

Figure 7: Drainage findings from a drone flight in January 2019

Crop health and growth through NDVI was also monitored over the life of the crop using a drone. NDVI always ranges from -1 to +1, and the closer to +1 the more healthy and dense the vegetation cover. Figure 8 shows the difference just one month can make in a short rotation crop like celery, with the NDVI value ranging from -0.03 to +0.06 in early December 2018 to +0.1 to +0.24 in early January 2019 (excluding furrows) approximately one month before harvest (the more green the better!).

Adam and Stuart were able to use this information to monitor crop uniformity after the staged planting dates, as well as identify any under-performing areas for closer investigation in the paddock (e.g. insect pest damage, waterlogging).

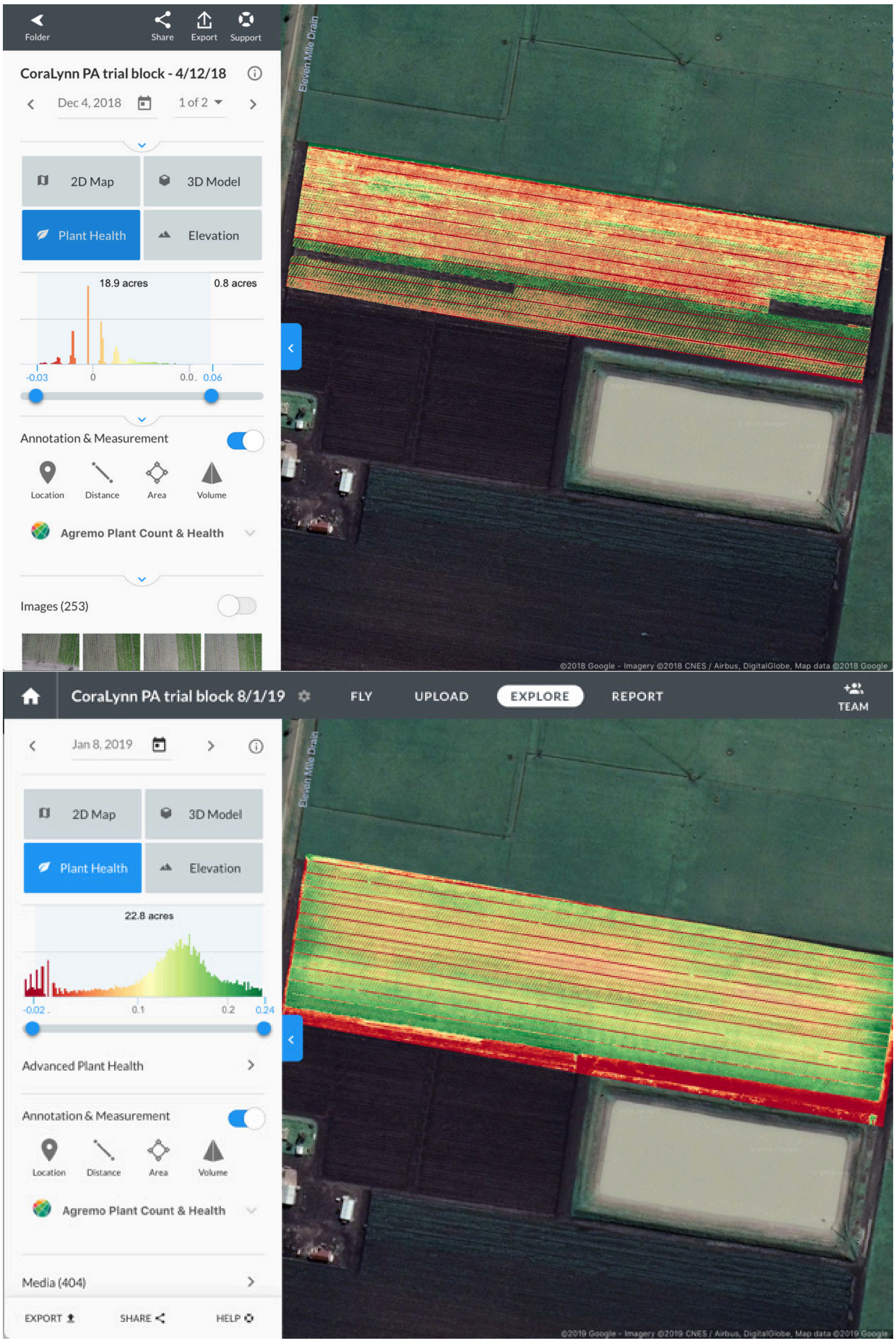

Figure 8: Tracking crop health using NDVI imagery with a drone over December (top) and January (bottom)

Plant tissue testing

Plant analysis provides information about actual nutrient uptake. With the cash crop approaching maturity, it was important to determine if the more precise nutrition and drainage management approach corresponded to improvements and consistency in the celery nutrient uptake.

Plant tissue samples were taken during late crop maturity in January 2019. A summary of the results for four different areas within the trial block are outlined in Table 3 below. This shows a slight difference in Bay 1 compared to Bays 6 and 7, due to Bay 1 having more variable inherent soil chemistry in the north than Bays 6 and 7 in the central and southern areas. This highlights the benefit of variable rate fertiliser application in more variable areas of the farm, which may have resulted in more consistent N, P and K uptake.

Higher Ca uptake across all bays may also have led to less issues with black heart in the celery compared to previous years according to Adam, which is also a huge benefit leading to higher marketable yield.

Table 3: Plant tissue analysis results for the main nutrients from January 2019

Analyte	**Bay 1 (S10-15)** Variable SOP (0-250kg/ha)	**Bay 1 (S26-30)** Variable SOP (0-250kg/ha)	**Bay 6 (S10-15)** 250kg/ha SOP	**Bay 7 (S10-15)** 500kg/ha SOP
Total Nitrogen (N) (%)	3.80	3.60	3.40	3.20
Phosphorous (P) (%)	0.35	0.37	0.38	0.41
Potassium (K) (%)	3.30	3.50	2.80	2.30
Sulphur (S) (%)	1.70	1.40	2.20	2.50
Calcium (Ca) (%)	2.40	2.20	2.60	2.90
Sodium (Na) (%)	0.78	0.80	1.30	1.50

Installation and use of remote monitoring insect traps

With eight farms in year-round production, it's often hard for Adam to monitor insect pest pressure for crop health at each location. You can only be in one place at one time! That's why the team decided to trial an insect trap that could be remotely monitored using solar-powered cameras and an online software platform to view the images.

The system was installed in August 2018 (Figure 9), and took two images per day from two different traps that were then uploaded to a cloud-based software system. The two traps were an external plate with yellow sticky paper, and an enclosed trap with white sticky paper and pheromone. Algorithms within the online software could also identify and be 'trained' to detect certain insect pests over time (Figure 10).

Figure 9: The remote monitoring insect trap being installed in August (left) and in full-swing during December 2018 (right)

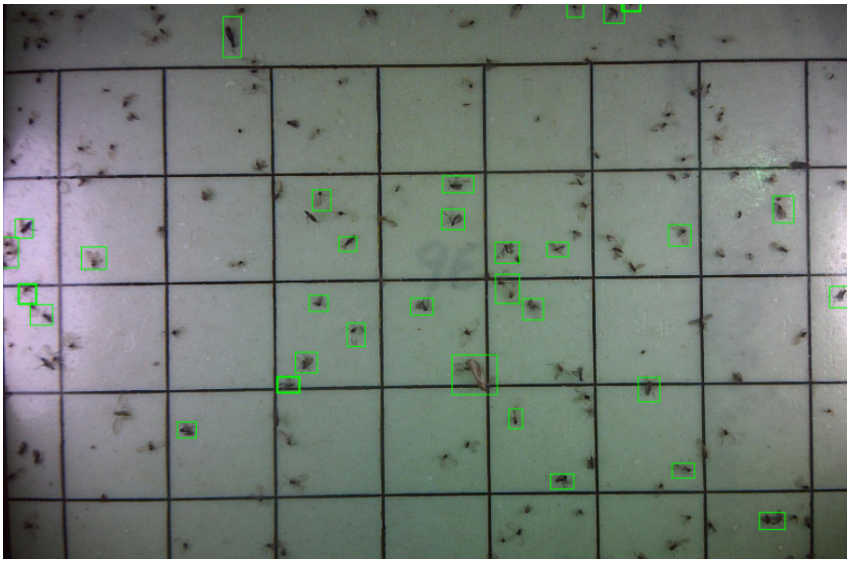
Figure 10: Algorithms automatically detecting different insect pest in the online software platform

Having the remote monitoring system allowed Adam, Stuart and their entomologist to cross-check the results from their traditional method of scouting within the trial block and other parts of the farm. During the growing season, there was moderate thrip pressure and feeding damage, a small number of flies and some Rutherglen bug identified using both monitoring techniques. However, due to the higher position in the crop, the remote station picked up smaller numbers of insect pest compared to the in-crop sticky and pheromone traps. A lesson for future cash crops is to lower the position of the unit so it is more representative of what the crop is experiencing.

Yield assessment

Did the precision agriculture activities lead to a better marketable yield in the trial block compared to the rest of the farm? That was the million-dollar question. To try and answer it, we undertook a yield assessment prior to harvest.

A total of 10 samples and five replicates were taken from the same locations within the trial block as the plant tissue testing for consistency.

There was higher average weight in the areas where there was less variable inherent soil chemistry, suggesting that variable rate fertiliser application has more value in more variable parts of the farm (Table 4). Interestingly, more SOP wasn't always better – the 250kg/ha rate yielded the best with an average weight of 640g compared to 500kg/ha (580g), possibly demonstrating diminishing returns. Some of the variation can be explained by the plantings in Bay 1 being slightly younger (only by a number of days) compared to Bays 6 and 7. It may also take more time to correct soil chemistry in the more variable northern areas.

Adam noted that "it's been a really even crop and come off really well … one of the best crops of celery we've had at this farm", and that in the past the crops "had always been a bit variable and patchy".

Table 4: Yield assessment results from January 2019

Location	Average weight (g)
Bay 1 (S10-15) Variable SOP	395.7
Bay 1 (S26-30) Variable SOP	406.5
Bay 6 (S10-15) 250kg/ha SOP	639.5
Bay 7 (S10-15) 500kg/ha SOP	580.0

Since the celery has been harvested, the trial block has now been planted to baby spinach (1/3) and leeks (2/3). Historically, Adam "haven't been able to grow spinach due to the pH issue, but it's all coming up and looking beautiful" in March 2019. The leeks have also established well, indicating the more precise management may be paying off for subsequent cash crops.

Figure 11: Late maturity celery during the yield assessment in January 2019

LESSONS LEARNT

Having gone through a full year of crop rotations, the team have learnt a number of lessons in implementing precision agriculture at the site. These include:

- Gridded and pre-plant soil testing allowed more detailed understanding of where nutrients are available to the plant
- Development of a nutrition program and variable rate spreading enabled precise nutrition application across smaller areas
- Drainage and crop health monitoring using drones meant problem areas could be identified and managed early before they impacted yield and the bottom line
- Plant tissue testing provided a useful cross-check to see what nutrients the plant had taken up and whether this varied across a paddock
- Installation and use of remote monitoring insect traps provided another 'safety net' cross-check for manual scouting. Placement lower in the crop is more effective
- Yield assessment showed higher average celery heart weights and more uniformity across the trial block.

NEXT STEPS

So, where to from here at the demo site? We're going to continue to implement the same precision agriculture activities over winter 2019 and track progress with the baby leaf and leek cash crops. It will also be important to incorporate the lessons learnt into the operation of the site – learning by doing is the best way of determining what works on your farm. This is one of the main benefits of the Soil Wealth ICP demo sites.

The site will then go under a cover crop in autumn, likely rye grass or rye corn, before celery is planted again about late September 2019.

For more information head to our website (https://www.soilwealth.com.au/demo-sites/koo-wee-rup-vic/), or keep an eye on the Facebook page for update and to track progress (https://www.facebook.com/SoilWealthICPKooWeeRup/).

Acknowledgements

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