Precision Agriculture for Vegetable Production

Department of Agriculture and Fisheries

August 2019

Highlights January – July 2019

Between January and June 2019, the project team finalised fieldwork for yield prediction sites with sweet corn in Bathurst and carrots in Tasmania. Activities at other demonstration sites are also finishing up and project staff are developing case studies on the range of PA technologies implemented across these sites such as:

- EM38 soil surveys in NSW, Victoria and SA,
- drones for plant counts and crop monitoring/ assessing variability in SE Qld,
- variable rate applications in Tasmania,
- training in the use of drones for PA in Central Qld.

The final six months of the project will focus on the collation of yield monitor data for WA, Qld and Tasmania, further extension activities, including a PA for Veg Grower Study Tour, and finalising demonstration site activities and case studies.

Queensland

Fassifern and Lockyer Valley, Qld

Retrospective satellite imagery of a sweet corn crop, classified into high and low vigour according to NDVI, was used to assess whether there had been any improvement in crop performance from variable rate (VR) compost applications. This site had previously identified that up to one third of the field was under-performing by up to 30%.

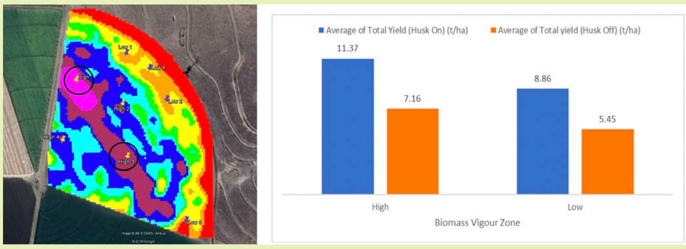

Figure 1. *Left:* *The NDVI processed satellite image of the corn crop in Kalbar.* ***Right:*** *Total cob yield assessment from high and low biomass zones. Note there was approximately 2.5 tonnes per ha differences between high and low cob yields (husk on).*

Hand harvested yield data at sample points from high and low vigour zones showed a marked difference in yield. There was a 2.5 t/ha (Husks on) and 1.7 t/ha (Husks off) difference between high (pink/blue areas) and low (yellow/red/orange areas) vigour areas (Figure 1).

Key findings included consistently greater biomass samples from the high zones (Figure 2) and more mature cobs (Figure 3). The grower claims that historical field operations and amendments, such as strip tillage, could have contributed to this effect in some points in the high biomass zone (High 1 and High 3 – circled in Figure 1).

Figure 2. *Comparison of biomass between low **(left)** and high **(right)** biomass vigour. Note the height difference of the plants.*

Figure 3. *De-husked corn cobs from a high **(left)** and low **(right)** vigour zone. Note the paler yellow colour in the cobs from the low vigour zone. The cobs within the red circles are primary cobs.*

While the grower feels that the area is improving through compost applications it is still under-performing relative to the rest of the field. Variable rate compost applications will continue and further investigation will look at some soil structural characteristics.

Mulgowie

Agronomists at Mulgowie Farming Company are exploring ways to use drone imagery in their day-to-day crop management. This includes potential applications such as crop biomass sensing to identify variability, and direct crop scouting and plant counts for hand harvested crops such as broccoli.

Crop sensing imagery successfully showed variability in a corn crop at two different crop stages (Figure 4), giving the agronomy staff confidence that the technology could be used to guide crop scouting. More detail in the early season imagery has highlighted that crop sensing early in corn gives a better indicator of variability than later in the season.

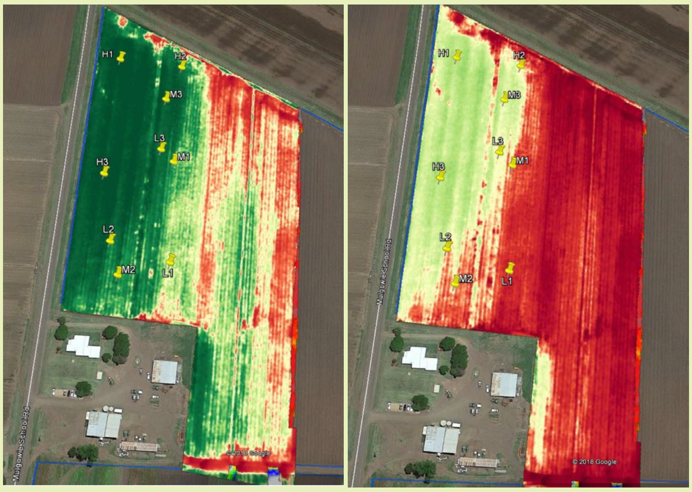

Figure 4. *NDVI imagery from the drone indicating biomass variability for two sweet corn plantings, as well as the variability within each planting.*

High resolution multi-spectral imagery of broccoli (Figure 5) showed the expected variation between planting dates but also variability within each planting. Automated plant counts are being followed through to maturity to compare with pack-out data and calculate field losses. This data will also provide Mulgowie with counts of their direct seeded broccoli, which can be more variable than transplants.

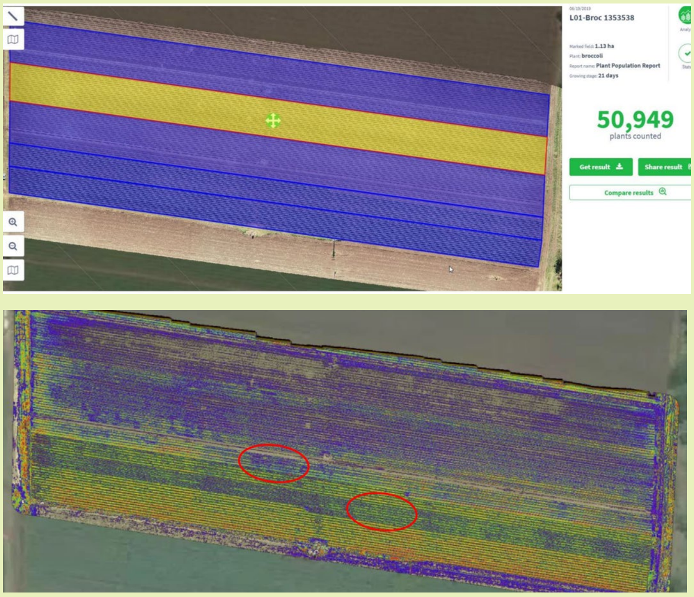

Figure 5. ***Top:*** *Automated plant count output from commercially available software. The count on the right hand panel indicates the number of plants within the yellow shaded area.* ***Bottom:*** *NDVI and NDRE in broccoli captured at 80m AGL(above ground level). Note variation in vigour within same planting date (circled in red).*

Key learnings include, the importance of timing, identifying how to use this information in their agronomic activities, and how to use the imagery for groundtruthing. Based on this work, Mulgowie are interested in trialing applications of similar crop sensing technologies at their farms in Bowen and Victoria.

AustChilli, Bundaberg

After purchasing a drone in early 2019, the AustChilli agronomy team has completed drone training with DAF staff and commercial drone operator Nat Parker, Airborne Insight. AustChilli is keen to incorporate drone applications, such as the use of crop sensing imagery for crop scouting and assessing spatial variability, into their agronomy operations.

Training covered the operational, regulatory and governance requirements for drone operation on farm. After allowing some time for the AustChilli agronomy

Figure 6. *Nat Parker (Airborn Insight) and the agronomy team from AustChilli on the training day in Bundaberg.*

team to undertake a range of test and practice flights, an additional training event will be held to focus on analysis and interpretation of drone imagery.

Western Australia

Center West, WA

Yield prediction field work was completed at Center West Exports' Sun City Farm at Woodridge in late 2018. The focus now is to collate and interpret the large amount of data collected from field sampling. Logging and processing of yield monitor data continued during this period. Data is made available to the grower as it is processed. There are still some ongoing challenges with respect to the accuracy of absolute tonnages from this yield monitor, which project staff in conjunction with the commercial partner, are continuing to investigate.

South Australia

Samwell and Sons

Based on previous EM38 soil mapping, Brussel sprouts were hand harvested across the different soil types identified. Samples were taken from three topographical and soil-type locations: top of the hill (sandy), break of the slope (sandy) and the flat (sandy loam). Although sprouts were not fully mature at the time of sampling, the samples collected still enabled a comparison between the sites (Figure 7).

Figure 7. *Variability in sprouts from different soil types indicated by EM38 soil mapping. Sprouts harvested from the top of the hill **(left)** and flat **(right)**. Sprouts are laid out from the bottom of the plant **(top of the image)** to the top of the plant **(bottom of the image)**.*

Figure 8. *Physical observations of crop height in Brussels sprouts at the top of the hill **(left)** and bottom of the hill **(right)**.*

Sprouts taken from the top of the hill were, on average, 2 mm smaller and 2 g lighter than those sampled from the flat (Figure 8). This would indicate that soil type may be driving the variability in the field, which supports anecdotal information from Scott Samwell.

While, crop variability associated with soil type was evident, Samwell and Sons have developed markets for a range of different sized sprouts such that this variability in size and or maturity does not result in significant production losses. If Samwell and Sons did want to manage this variability in the future, the potential management options identified during discussions with Samwell and Sons include:

- installation of soil moisture monitoring equipment,
- variable rate irrigation to suit the dune-swale system,
- spreading clay over the sandier areas of the pivot to reduce leaching.

Musolinos

EM38 soil surveys identified significant areas of high electrical conductivity (EC), which groundtruthing confirmed to be high salinity.

Soil analysis identified several issues with potential management implications:

- Three soil types were determined from the 20 samples taken from the field, ranging from a moderate to deep brown sandy clay loam over medium to light-medium clay, to brown light clay topsoil over medium to light medium clay.
- Generally the topsoil was low in phosphorus, zinc and, in some areas, copper.
- High levels of salinity, chloride, exchangeable sodium and boron were found in most subsoil and some topsoil samples. These were at levels likely to affect plant growth and viability, as was evident in significantly lower field recovery of cabbage in these areas (only assessed visually) due to tip burn.
- Point 19 (black circle on Figure 9) is outside the cropped area and, with the extremely high readings at this site, indicates that irrigated cropping in this field is contributing to the salinity in the soil through the leaching of salts from the crop zone. This is supported by a higher level of apparent EC in the 0.75–1.5 m EM38 mapping layer.

Project staff met with grower Chris Musolino to review the results. While the Musolinos were aware that this field had significant issues impacting on productivity, particularly salinity, mapping of the field has meant that Chris and his agronomist can now put in place strategies to minimise and address these issues where possible, based on this spatial information. Management strategies discussed with Musolinos include:

- increasing the organic matter in the field through cover crops in the rotation,

- target areas of low EC to be planted first,
- using salt-tolerant crop types in most saline areas to reduce crop losses.

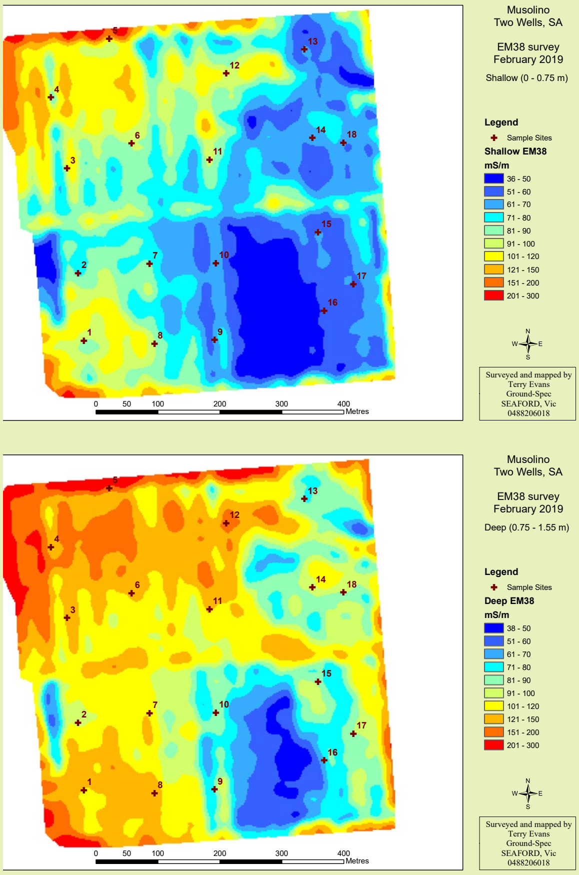

Figure 9. *EM38 soil mapping at 0–0.75 m* ***(top)*** *and 0.75–1.5 m* ***(bottom)****. Note blue areas of low apparent electrical conductivity and red areas of high apparent electrical conductivity. Points on the map denote soil sampling points for ground-truthing and crop sampling sites.*

Victoria

Fresh Select Farms

Ben Fleay and his team from Precision Agriculture (Ballarat) completed two EM38 soil surveys (to accommodate different crop rotations) to create one spatial layer for a field at Fresh Select, Werribee (Figure 10). Fresh Select and agronomist Stuart Griggs were interested in confirming the extent of salinity and providing spatial detail for potential management options. Issues within the field included poor drainage resulting in near-waterlogging conditions in sections, and the presence of salinity, which was attributed to both irrigation water and the proximity to Melbourne's inner west coast. Soil sampling to ground-truth this mapping will be completed in August 2019.

Tasmania

The following demonstrations of precision agriculture technology will be developed into case studies.

Greenvale Pastoral – Cressy

Repeat grid mapping of pH, P and K has occurred on

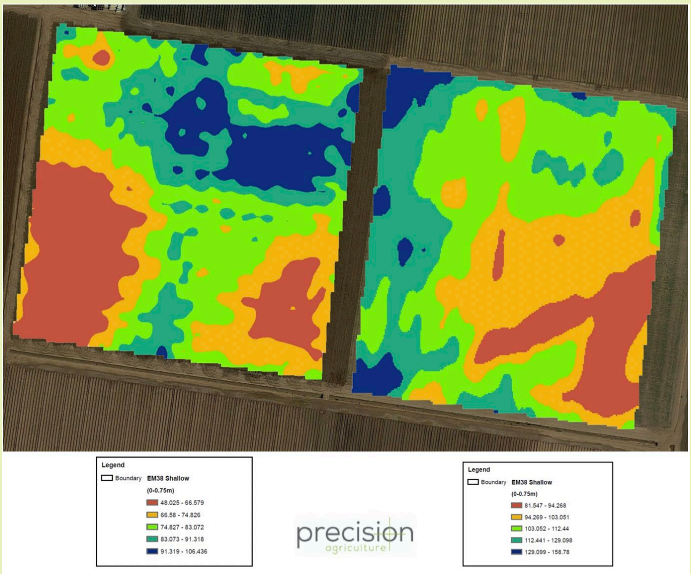

Figure 10. *EM38 soil mapping at Fresh Select Farms. The red areas in the map indicate low EC levels in the field, dark green to dark blue areas indicate high soil EC.*

a number of paddocks with varying history of field management (i.e. differing periods between first and second mapping, and VR applications after the first mapping). Discussions around detailed analysis and data interpretation is planned for July/August 2019 with service provider AgLogic.

Two field walks have been held at this site, in conjunction with AgLogic, to highlight the precision drainage work undertaken at Greenvale Pastoral (Figure 11).

This work was undertaken to alleviate waterlogging, which is the biggest cause of crop loss in this production system.

Figure 11. *Images from the field walks at Greenvale Pastoral.*

David Whishaw (Armidale Pty Ltd)

A second round of Veris® mapping has been undertaken following initial Veris® mapping and VR applications of lime to address variable soil pH. This mapping indicates that the application of lime has raised the soil pH (Figure 12).

Harvest Moon

Fieldwork for the carrot yield prediction component was finalised in February 2019 at Harvest Moon and maps of predicted yield were distributed to Harvest Moon. As Harvest Moon was also logging yield monitor

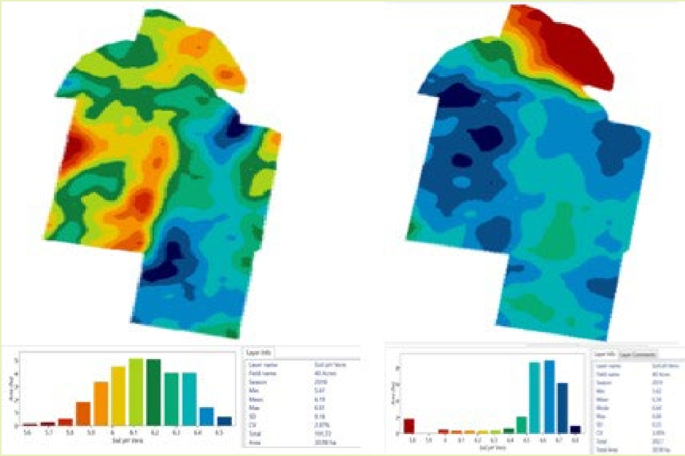

Figure 12. *Pre-VR lime application soil pH map **(left)** and post-VR lime application soil pH map **(right)**.*

data, comparison of predicted yields with commercially harvested yields saw high accuracy in the 2018 data (92% across 5 fields – Fields 710 to 716 in Figure 13), however, greater discrepancies were seen in 2019 data (Fields 811 to 813 in Figure 13). This was attributed to taring issues with the yield monitor when data was logged.

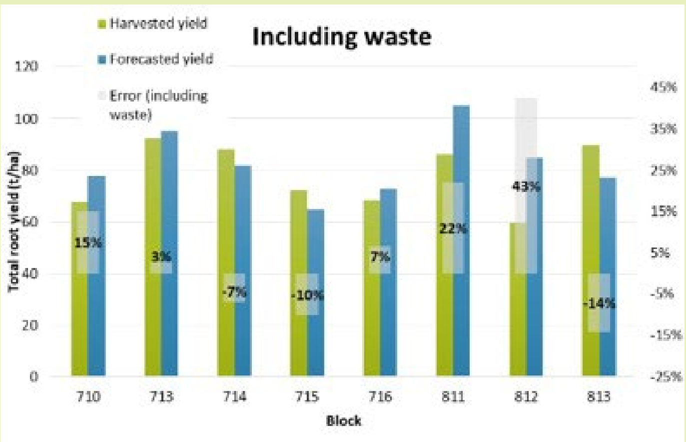

Figure 13. *Yield forecast vs. harvested yield for 2018 and 2019 combined carrot crops.*

The overall accuracy of 85% for predicted yields from Tasmania over 2018 and 2019 highlights the potential for early season forecasts using remote sensing to be a valuable tool for growers to use in their farming operations.

Gibson Ag – Hagley

Soil Information System (SIS) mapping was completed in March 2019 to assess its value as an aid to subsurface drainage design. All mapping data have been provided, but the derived drainage design is not yet complete. The installation of subsurface drainage is planned for 2020.

Addison Farms – Moriarty

Drainage mapping using EM38 and elevation data was completed in a number of fields to direct the mapping of sub-surface drainage. The drainage has been installed for the purpose of managing perennial springs that cause intermittent waterlogging in the field.

New South Wales

Richmond, Sydney

Sam and Val Micallef are a family operation in Richmond, near Sydney, produced a range of leafy vegetables. Sam and Val were interested in using EM38 soil mapping to better understand the variability that they knew existed across their farm. Due to the variations in planting times and the layout of the farm, the survey was completed over three dates, to fit around crop rotations (Figure 14).

The following observations were made from the soil sampling and analysis from GPS reference points in each EM zone:

- Four soil types were identified across the farm – loam, sandy-loam, loamy-sand and sand.
- There was a 40% variation in water-holding capacity across the different soil types (not measured, based on soil type classifications), with some soil types potentially holding up to 2.5 times the water held in other soil types.
- While not technically sodic, based on critical limits for exchangeable sodium percentage (ESP), a combination of higher exchangeable sodium and a higher clay content are contributing to reduced water infiltration and soil surface crusting in areas high in EC.

Figure 14. ***Left:*** *the EM38 soil map with overlaid sample points (black dots).* ***Top right:*** *An EM38 sensor being towed behind a tractor.* ***Bottom right:*** *Ground-truthing at Alandale (Source: Precision Pastures 2019).*

- Soil pH in some areas is sufficiently low to have potential to cause club root issues (with club root more virulent at soil pH < 7.

Table 1. Representative sample points from the high, medium and low EM38 zones, showing differences in pH, Exchangeable sodium percentage (ESP) and EC (dS/m) from 0–30cm depth.

Sample point	pH (1:5 $CaCl_2$)		ESP %		EC (dS/m)	
	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
H15	5.8	6.0	4.4	0.4	0.23	0.55
M11	6.2	6.6	3.6	2.8	0.11	0.12
L3	5.8	4.9	2.2	3.0	0.11	0.09

The Micallefs have spread lime at variable rates (250 kg/ha in high pH and 400 kg/ha in low pH areas) to address low soil pH zones. This was done by manually adjusting rates in different areas of the farm. Gypsum has also been applied at variable rates of 1.5 t/ha across the farm with a higher rate of 2.5 t/ha in areas of low infiltration. Their strip tillage program and retention of crop residues will also assist with improving soil characteristics. The Micallefs are also varying irrigation application rates across fields by varying sprinkler nozzles in response to soil moisture monitoring by the Soil Wealth project and will use soil textural differences to refine this further.

Communication activities

The project team have been involved with many communications activities, including:

- An article about using UAVs for plant counts was published in Vegetables Australia May/June 2019 (pg 42 to 43).
- Advertising the grower tour in the WA Grower and Vegetables Australia magazines.
- Celia van Sprang (DAF) and Angelica Suarez Cadavid (UNE) presented at the PA Expo in Tasmania on 17 April, co-facilitated by John McPhee (TIA).
- Julie O'Halloran (DAF Qld) presented at the Society for Precision Agriculture Australia workshop in Bowen.
- Several twitter updates were released, see #PA4Veg.

Where to from here?

Case studies from demonstration sites and videos will be developed in the next project period. Stakeholders involved in the project will be asked to complete a short, end-of-project survey to help capture impacts and feedback from the current project as well as insights for any future work.

Grower tour

The project team are excited to be facilitating a Grower Study Tour from 4 to 11 September to SA, Victoria and Tasmania to see the different ways innovation and agtech can be implemented on farm. Tour participants will also attend the SPAA Symposium 2019 in Launceston to finish off the tour. Currently, there are 16 participants confirmed for the tour. Representatives from Hort Innovation will also join the tour.

For more information about 'Adoption of precision systems technology in vegetable production (VG16009)', contact the team:

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