Using soil sensing technologies to understand irrigation requirements

Department of Agriculture and Fisheries

Jack Abbott, Aratula Queensland

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Grower: Jack Abbott

Location: Aratula, Queensland

Area: 120 ha

What they grow: sweet corn, beans, carrots, pumpkins, onions

Soils: dark clays with some lighter textured soils (loams)

Topography: alluvial flats

Average annual rainfall: 905 mm

Precision technologies implemented: EM38 soil mapping, Wildeye soil moisture sensors

Key outcomes

- EM38 soil mapping can be used to locate soil moisture monitors based on soil differences.
- Understanding soil texture, crop water interactions and requirements can identify opportunities for water and pumping cost savings.
- Real-time dashboard gives the opportunity to monitor soil moisture changes at different crop growth stages and respond to alerts.
- Growers and supply chain service providers working together to enhance understanding and implementation of precision technologies.

Background

Prior to his involvement in this project, Jack had had very little exposure to precision agriculture technologies.

The soils in this area are generally alluvial clay soils, with some loamy soils contributing to variability. This site was selected based on information from Jack that there was variability in the field that contributed to differences in crop growth performance.

To better understand the variability, EM38 soil mapping was carried out with subsequent soil sampling to groundtruth the EM38 data.

Soil moisture sensors were installed to monitor soil moisture and plant water use in different parts of the field, and to demonstrate how soil moisture monitoring can be used as a tool for irrigation and water use management in vegetables.

Activities

EM38 soil survey

Electromagnetic (EM) soil mapping was carried out on the field of interest. The EM38 survey indicated three apparent EC (ECa) zones, which were classed as High (155–119.1 dS/m), Medium (119–89.63 dS/m) and Low (89.62–49.45 dS/m) (Figure 1).

Soil samples were collected from each ECa zone to groundtruth the EM38 data and determine whether the differences in ECa were due to soil salts, texture or soil moisture, or a combination of these characteristics.

Soil analysis at these groundtruthing points indicated that the differences in EM were not due to salinity (with little difference in measured EC between EM zones), so likely attributed to differences in clay and soil moisture content. However, the Medium and High sample points had exchangeable sodium percentages of 3–6%.

> *"It keeps the irrigator honest, being able to monitor irrigation applied."* – Jack Abbott

Soil moisture monitoring

To understand whether the variability indicated in the EM38 mapping was a reflection of soil water availability or not, capacitance soil moisture Teros 10 sensors

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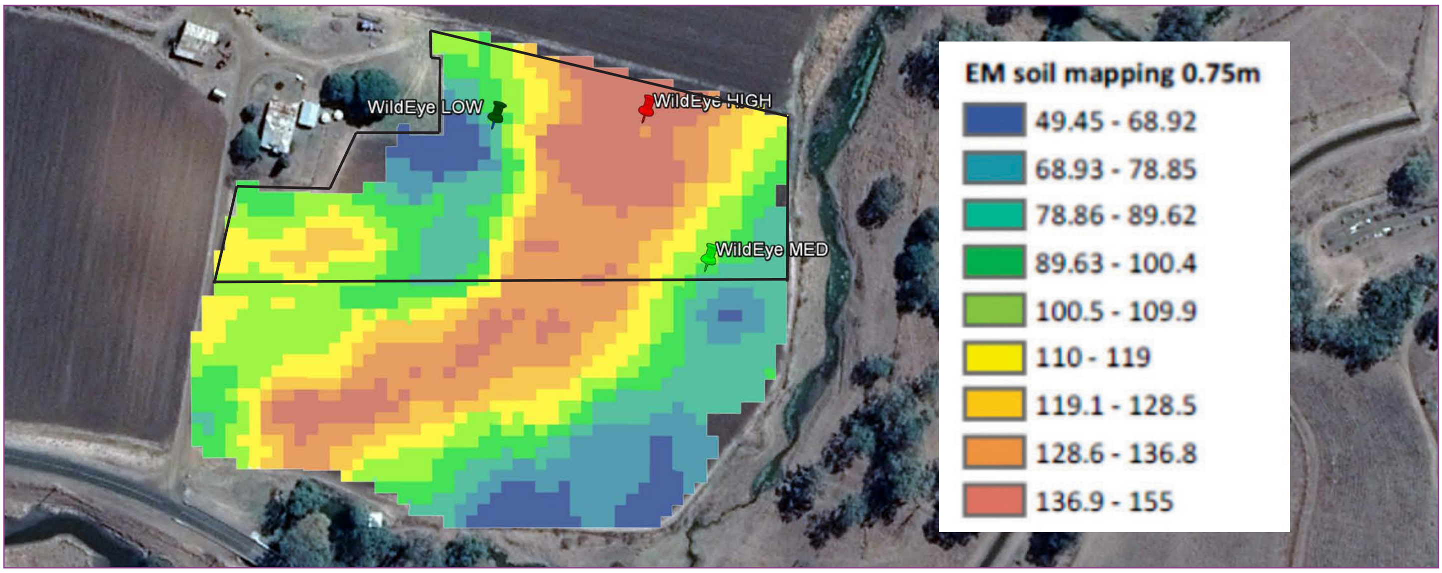

Figure 1. Wildeye installation sites in the EM38 mapped field. Blue areas indicate lower ECa and the red areas indicate higher ECa. The area within the black lines indicate sweet corn growing area.

Figure 2. The sensors are placed at 15 cm and 30 cm depths to measure the moisture at two levels in the corn root zone.

(Wildeyes™) were installed in a crop of sweet corn in each of the EM zones (Figure 1).

Three monitors, each fitted with two soil moisture sensors were installed in the field with sensors at two depths (15 cm and 30 cm) (Figure 2).

Rain gauges were attached to a 2 m pole to ensure that the canopy of the corn crop would not impede the capture of rain and irrigation water. Rain gauge and soil moisture sensor data was transferred telemetrically to an online dashboard, accessible via PC, tablet and smartphone.

Real-time data was recorded and graphed, showing soil moisture levels for each of the Low, Medium and High EM zones (Figure 4). Automated text messages were sent to alert Jack when soil moisture levels dropped below the refill point (set at 60% of field capacity in summer).

Soil analysis at soil sensor sites

Additional soil samples were taken at each of the soil sensor sites to assess soil characteristics that impact on soil-plant water interactions. Two soil cores were taken at each of the soil moisture sensor sites to approximately 60–80 cm (Figure 3).

The soil cores were tested for pH, EC, texture (sand, silt and clay percentages), field capacity (FC) and permanent wilting point (PWP).

Evidence of soil compaction was observed in all EM zones at approximately 25 cm depth, a legacy of a wet harvest in previous years (Figure 3). This is evident from the observation that tap roots were seen only up to 35 cm in the High EM zone. However, the same was observed up to 60 cm in the Low EM zone. Although the compaction did not appear to affect overall crop growth, restricted access to moisture and nutrients below the compaction line has the potential to affect yield and quality.

Laboratory analysis indicated EC was higher at 40–60 cm in the High EM zone, although this would not be considered saline (0.42 dS/m c.f. 0.16 dS/m). Additionally, there were some subtle differences in soil texture, with a higher percentage clay content in the High EM zone (61.4 c.f. 41.5%), and higher fine (32.6 c.f. 17.1%) and coarse (6 c.f. 2.5%) sand content in the Low EM zone, particularly at 20–40 cm depth.

Parameters FC and PWP and plant available water (PAW) were calculated from the soil analysis results. At the 20–40 cm depth, PAW differed by 16 mm across the EM zones, with a PAW of 105 mm for the Low EM and 121 mm for the High EM sites.

Interpretation of soil moisture data

Soil moisture data at Low and High EM zones in the first four weeks of crop establishment and growth indicated that soil moisture was maintained above 80% of FC at

Figure 3. Left – Soil cores from the Low (top) and High (lower) EC zones. Right – An example of sweet corn tap roots found at or below 25 cm depth.

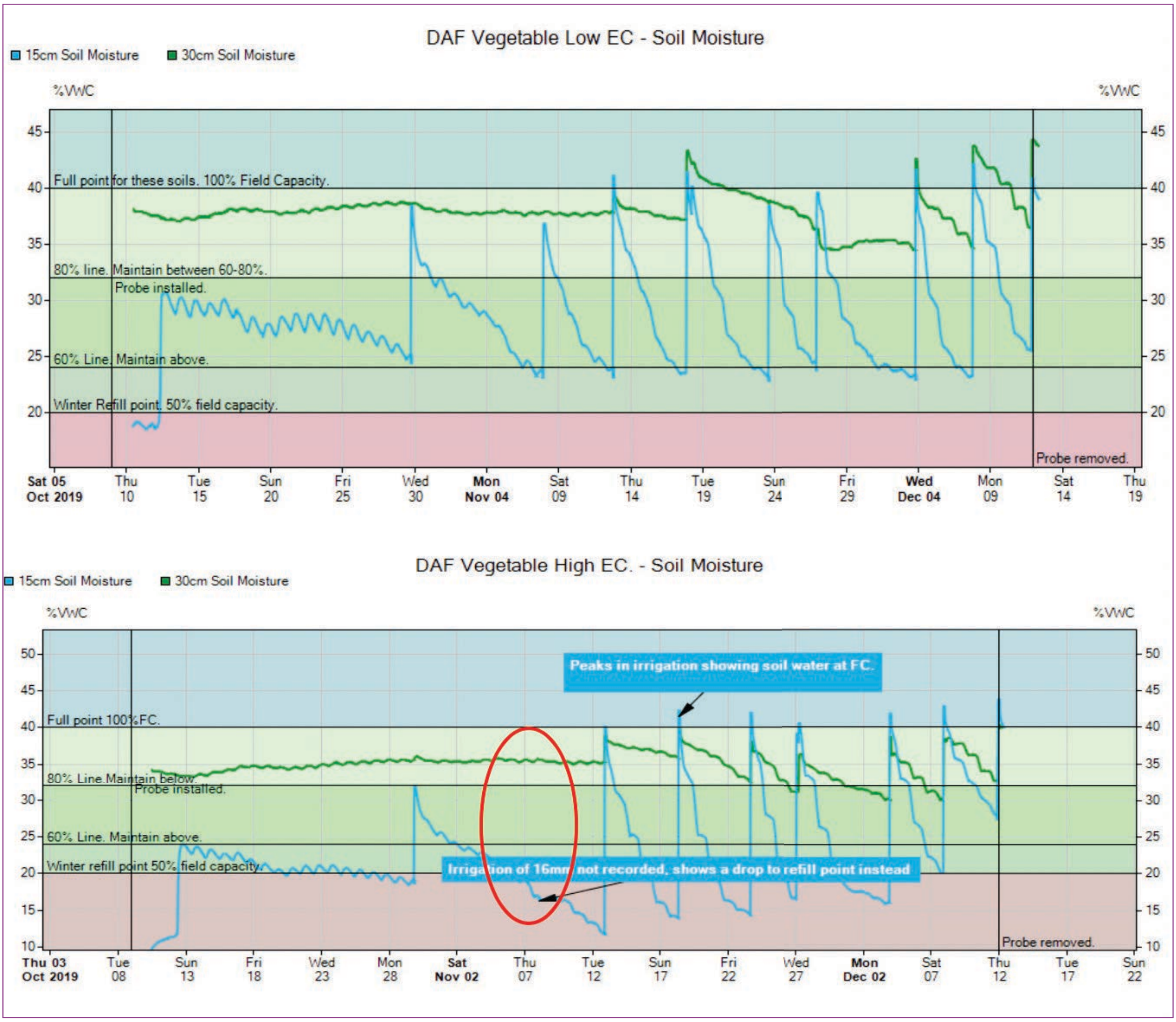

Figure 4. Soil moisture trends throughout the crop at 15 cm and 30 cm for Low EM zone (top) and High EM zone (bottom). Red circle indicates an irrigation not recorded due to low soil-probe contact in a drier clay layer, causing air pockets around the sensor.

Table 1. Comparison of water requirements for sweet corn at different growth stages to the applied irrigation and rainfall recorded through Wildeye.

Days after planting	Growth stages	Crop water use (ETc* Kc) (mm)	Total water applied (mm)	
			Low EC	High EC
0–7	seedling	9.90	9.60	10.00
7–40	0.1 to 0.7 m	27.15	19.40	17.40
40–50	0.7 m to silking	97.95	12.20	13.00
50–60	silking to grain fill	58.20	30.20	28.40
60–70	grain fill	62.45	39.20	35.20
70–80	maturity	–	70.60	72.00
Total			**239.40**	**#228.20**

*Total water applied includes both irrigation and rainfall as measured by the Wildeye.
This does not include the irrigation missed by the air pocket around the High EM probe early in the crop.

30 cm depth (Figure 4). This suggests that there is an opportunity for irrigation savings early in the crop, due to the young crop still establishing and not yet drawing moisture from the 30cm depth. This could save 10 to 15 mm of water for the first three or four irrigations in both the Low and High EM zones, depending on the impact of weather conditions on crop establishment (e.g. hot and dry conditions).

The at 20–40 cm depth in the High EM zone exhibited a higher clay content, which is likely to hold more water and explain the higher ECa in this zone as detected by the EM38 mapping. However, the higher clay content also makes this soil more susceptible to compaction, which was evident at 20–35 cm in this area.

This could limit water availability from the 20–35 cm zone or make it harder for the crop to extract water from this depth, hence the higher draw of moisture at the 15 cm sensor, which regularly drops below the refill point. While this might highlight differences in the soil moisture holding characteristics across the field, Jack still has to irrigate to the field average in the absence of variable rate irrigation capability.

The real-time online dashboard allowed daily monitoring of soil moisture status. Jack’s irrigation strategy aims to supply 2.5 ML per ha (250 mm). Jack would still check the field regularly to see how the sensor readings related to soil moisture in the field.

It is important to understand crop water requirements at different stages of the crop, along with evapotranspiration and soil-plant-water interactions.

Establishment, silking, grain filling and maturity are the key stages of growth that require adequate irrigation in sweet corn. The total applied irrigation for sweet corn at different stages were calculated from the Wildeye dashboard, along with daily evapotranspiration in the Low and High EM zones (Table 1).

Yield samples

Yield samples were collected to determine if there was any difference between EM zones and to potentially relate yield to crop water use.

Although there was little yield difference between the EM zones, there were differences in the numbers of primary and secondary cobs. The High EM zone had an equal number of primary and secondary cobs, while the Low EM zone had 25% more secondary cobs than primary. It is likely that a greater proportion of these secondary cobs would not meet specifications.

Yield differences may be related to a combination of the variation in PAW and compaction across the field.

Challenges

The challenge with soil monitoring technology is how the data can be interpreted. Issues can sometimes arise with sensor installation. At this site one of the sensors (High EM, 30 cm) did not record an irrigation event and showed a dip in the moisture levels. With further investigation, it was found that the wetting and drying of the clay around the probe caused air pockets surrounding the sensor at 15 cm. This restricted probe-soil contact and provided a false reading.

Key learnings

- EM38 and appropriate soil sampling provides an accurate method to determine the placement of the soil moisture sensors.
- Having sensors placed at each extreme of the ECa range can provide an indication of how varying soil characteristics have different soil-plant-water interactions in each zone.
- Incorporating rain gauge sensors as part of the soil moisture monitor illustrated how rainfall contributes to the soil moisture profile and PAW.
- Having the ability to monitor soil moisture across the field provides a means of managing water use,

irrigation scheduling, identifying critical stages for watering, over- and under-watering, and potentially targeting irrigation rates in certain areas of the field with variable rate irrigation technologies.

- Jack sees this case study as a positive learning experience and is interested in continuing to use this technology in other crops. The text messages provided him with real-time alerts, and it is a tool that he can use to save time compared to manually checking the irrigator.
- The soil coring at soil sensor sites also provided an opportunity to demonstrate the concepts of FC, PWP and refill point in relation to Jack's soil texture, including the soil compaction and root penetration.

Cost

The costs associated with EM38 soil mapping vary with the service provider. In this case they averaged $50/ha. The rain gauge and soil moisture monitors were approximately $1500 per unit including two sensors (which can be installed as different depths), the annual subscription for each unit and access to the dashboard.

Service providers: Wildeye™ Team – Rob Abbas (Queensland) and Kieran Coupe (Western Australia) and Premise™ for EM38 mapping (Tim Neale)

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Costs presented in this document were accurate as of October 2019. These will change over time and between data processing service providers.

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