POTATO CASE STUDY PART I
MAY 2020

SoilWealth NURTURING CROPS | Integrated Crop Protection PROTECTING CROPS

Irrigation monitoring in potatoes:

Practical use of IrriSAT and soil moisture sensors

This case study explains how the irrigation tool, IrriSAT, combined with soil moisture monitoring, provided important information to the grower about crop water requirements and actual soil moisture levels. This enabled him to manage his crop irrigation to maximise yield and quality.

KEY FINDINGS FROM THE CASE STUDY

- **Crop water requirement changes rapidly as the crop develops – be prepared for the 4-fold increase in crop water needs:** Daily crop water was less than 2 mm/day during the sprouting and emergence stage. Over two weeks the daily water use increased from 2 mm/day to over 8 mm/day – a 4-fold increase. Make sure you bring your soil back to field capacity before the rapid vegetative crop growth stage.
- **After row closure, changes in the weather become the major driver in daily crop water use.** Hot dry Norwest winds push crop daily water use to over 11 mm/day, with cooler changes and showers dropping crop water use to 6 mm/day. With peak crop water demand pushing the limits of most irrigation systems, short periods of lower crop water demand associated with cool changes can be used to catch up and refill the soil.
- **A common trap for growers is to delay restarting irrigation after rainfall.** After 20 mm of rain in mid-January, irrigation was not restarted for seven days, resulting in the crop going into water stress during the critical bulking up stage. This drove the soil moisture to their lowest levels during the sensitive tuber bulking up stage. We estimate that yield losses of 10% resulted from the delayed restart of irrigation after the rain. ***Across the half pivot, the yield losses could have been between $12,600 and $17,900.***
- **IrriSAT provides a useful tool for monitoring crop growth and water use.** IrriSAT is easy to use and provides useful information on crop growth, 7-day forecasts of crop water use to help with planning and can also be used to check for variability across the paddock. A major strength is the coverage of the whole paddock using the satellite information.
- **Soil moisture sensors provide a good spot check on soil moisture conditions.** As with all soil moisture monitoring, it is important to choose the right location in the paddock at appropriate soil depths and correctly install the sensors.

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About the farm

The 1,000 ha farm is located at Billimari near Cowra, NSW, on loam and sandy loam soils. It has been producing processing potatoes (var. Snowden) for the past nine years and the grower was interested in trying some new tools to manage his irrigation.

What was done

Marc Hinderager and Dr Kelvin Montagu from AHR's Soil Wealth team were interested in how the satellite-based irrigation scheduling app, **IrriSAT**™, which estimates the daily crop water needs, could be combined with tools which measure soil moisture directly in the root zone of the crop. https://irrisat-cloud.appspot.com/

The direct soil moisture measurement tool they chose was the **Wildeye**™ system which uses a technique known as TDI (time domain reflectometry) to measure soil moisture at two depths, and uploads the data to a website for access www.mywildeye.com/. The project team do not endorse Wildeye over other soil moisture monitoring systems.

The crop was planted on the 27 October 2019 on half an irrigation pivot (13 ha). Two soil moisture sensors were installed in the half pivot on the 10 December 2019, 44 days after planting, and were monitored throughout until the crop was harvest on the 15 February 2020. The IrriSAT app was used on the same area from planting to harvest.

This demonstration followed a large potato grower's pivot irrigation practice on variable sandy loam to loam soils. Based on information from IrriSAT and soil moisture monitoring, Marc and Kelvin provided the grower with useful information about irrigation requirements for this crop, aiming to keep within the allowable depletion amounts and field capacity range of 65% to 85% soil moisture. Ultimately, all decisions were made by the grower and documented for learning and sharing in this case study. The tech box at the end provides more details of the crop and tools used.

How IrriSAT works

IrriSAT uses satellite images of your crop to monitor crop growth stages and calculate a crop factor (K_c). The crop factor is then used to adjust daily reference evapotranspiration (ET_o) data from the Bureau of Meteorology to estimate your crop water use each day (mm/day). Importantly, IrriSAT will also predict crop water use for the next seven days, based on weather forecasts.

IrriSAT also keeps track of rainfall and irrigation and combines this with crop water use to produce a soil water budget. This can help guide your irrigation frequency and show when the soil may be drying to below the refill point.

Figure 1A shows examples of the IrriSAT satellite images of the potato half-pivot at Cowra from November 2019 to February 2020. It also produces an actual crop growth curve for your crop based on the crop factor, which is calculated from NDVI (Figure 1B). The crop factor is used to adjust reference evapotranspiration into crop water use – see the tech box at the end for more information.

IrriSAT also keeps track of rainfall and irrigation and combines this with crop water use to produce a soil water budget (red). This can help guide your irrigation frequency and show when the soil may be drying to below the refill point.

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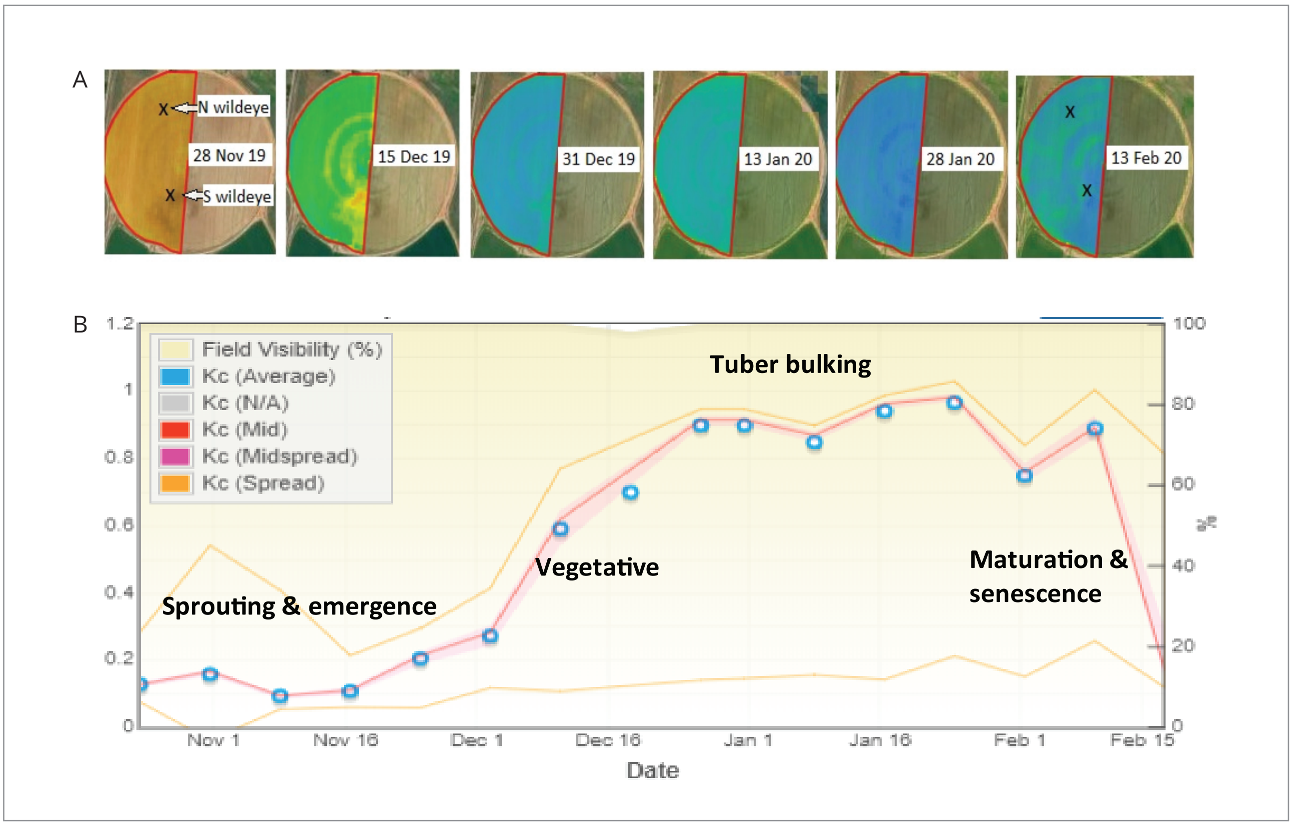

Figure 1. IrriSAT fortnightly time-series of crop factors produced from satellite data (A), and crop factor over time with potato growth phases added (B). In A, x indicates location of soil moisture sensor (N = northern; S = southern). Legend for time-lapse of IrriSAT images: K_c = 0.2 (brown, bare soil); K_c = 1.2 (blue, maximum ground cover).

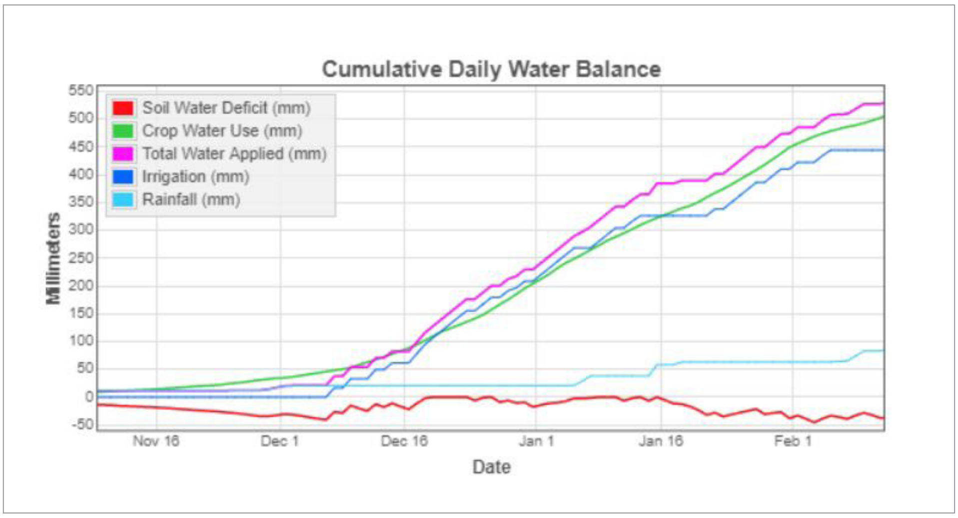

Figure 2. IrriSAT cumulative daily water balance from planting (1 November 2019) through to harvest (19 February 2020).

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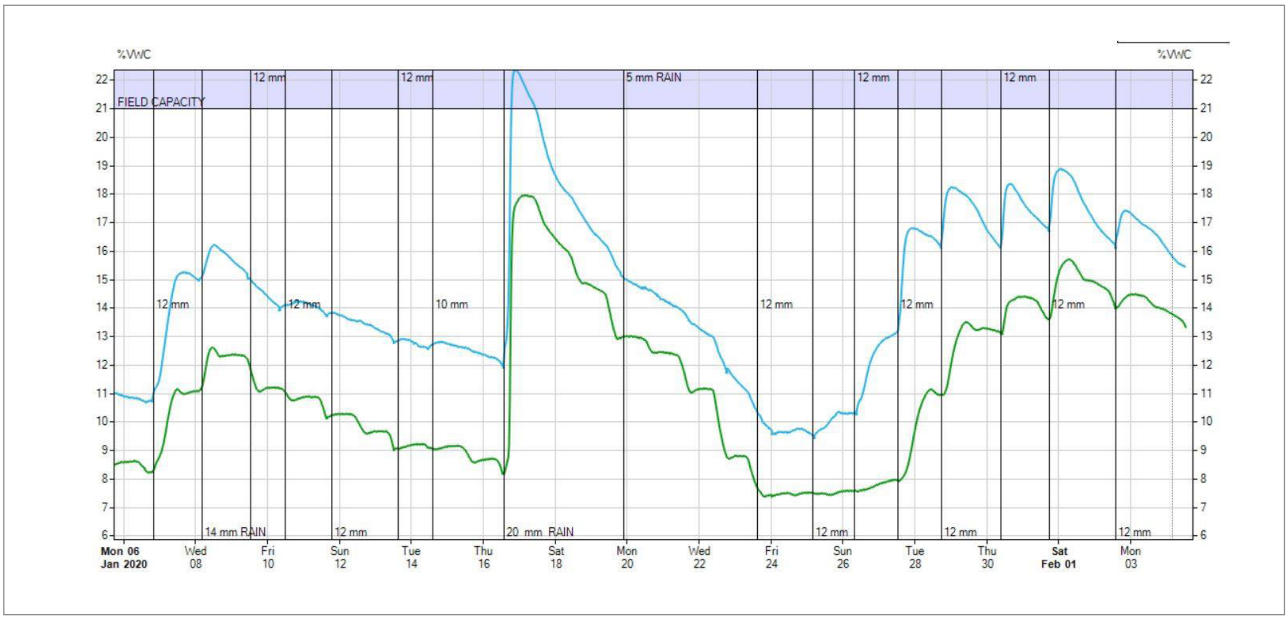

Figure 3. Soil moisture data in the potato pivot at Cowra, January to February 2020. The blue line is 20 cm depth and the green line 50 cm depth. Irrigation and rainfall are added as vertical lines.

Soil moisture sensors and some key results

Two soil moisture sensors were installed in the root zone of the crop at 20 cm and 50 cm depth. They track soil moisture in real time and show from where in the soil profile the water is being taken up. You can see how deep irrigations and rainfall events are penetrating into the soil, which helps you understand how long you need to irrigate to refill the soil profile (Figure 3).

The soil moisture sensors can also indicate what time of day roots are using soil moisture. Zooming into the daily water use on hot summer days shows that most water uptake occurs from early morning through to noon, after which plants began to physiologically shut down due to the heat (Figure 4).

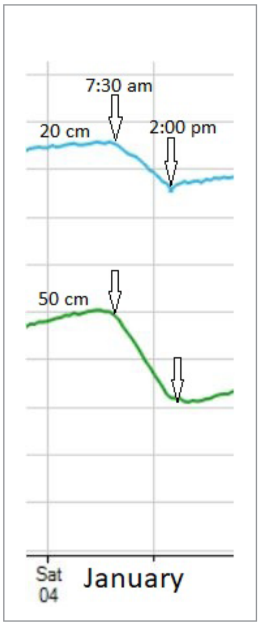

Figure 4. Changes in soil moisture during the day for 4 January 2020. Max temperature = 44.6 °C.

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So, what happened during the 2019/20 summer season in Cowra

The description below outlines what happened during the four main phases of the crop:

- Sprouting and emergence
- Vegetative
- Tuber bulking
- Maturation and vine senescence

And how these stages relate to crop water use calculated by IrriSAT (Figure 5).

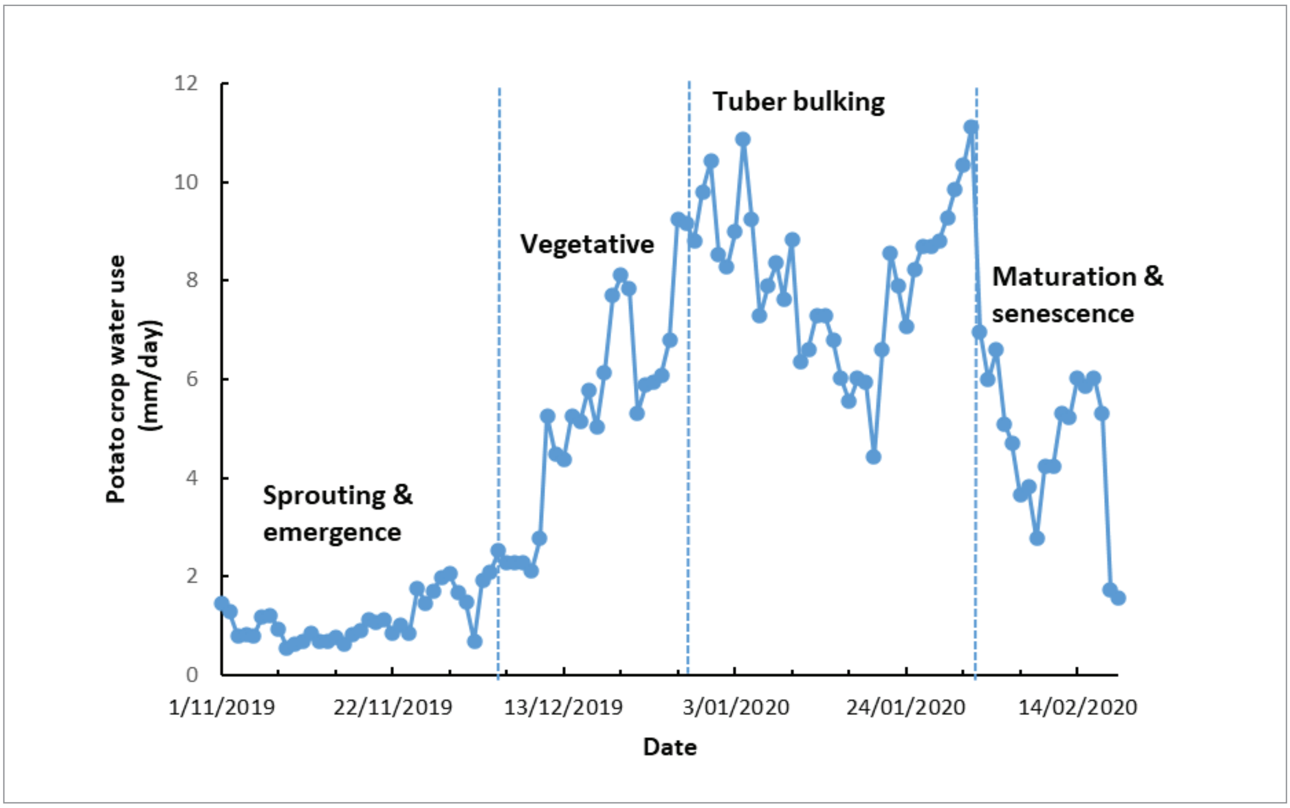

Figure 5. Potato daily crop water (mm/day) estimated by IrriSAT using crop factor and reference evapotranspiration (ET_o) from weather data.

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Sprouting and emergence – disease management a priority

During the first 30 days, the sprouting and emergence stage, the soil needs to be kept reasonably dry to prevent diseases like *Rhizoctonia* developing. Early crop growth relies on water stored in the seed piece and roots growing into new soil for moisture, with no irrigation applied. But irrigation needs to be started early enough to bring the soil back up to field capacity before crop growth really takes off during the vegetative stage. Getting this balance right is difficult and, in this case, was further complicated by 9 mm of rainfall near the end of the emergence stage. A common trap for growers is to delay starting irrigation after rainfall.

Vegetative stage – crop growth driving water use

In this case study, the potato crop entered the vegetative stage with a more than 40 mm soil moisture deficit. This was the result of a delay in starting irrigation, probably due to 9 mm of rain, potentially slowing early growth and costing yield.

During the vegetative stage, daily crop water use increased from less than 2 mm/day to over 8 mm/day – a 4-fold increase, in two weeks (Figure 2). This is largely driven by crop growth, rather than changes in weather, which highlights the benefits of IrriSAT's satellite monitoring producing the crop growth curve through the development of the crop factor (K_c; Figure 1).

To overcome the soil moisture deficit, the grower had to run the pivot hard to refill the soil and keep up with the rapidly increasing crop water use. During the three weeks of the vegetative stage, the grower applied 180 mm of irrigation. This got the crop back on track and set it up well for the critical tuber bulking stage during a hot January.

Tuber bulking – changes in weather driving water use

Once the canopy has closed over, the weather becomes the major driver in daily crop water use. Hot dry Norwest winds push crop daily water use to over 11 mm/day, with cooler changes and showers dropping crop water use to 6 mm/day.

Irrigation during this stage is about keeping up with peak crop demand, with any water stress reducing tuber growth and causing tuber malformations, diseases and hollow heart. With peak crop water demand pushing the limits of most irrigation systems, short periods of lower crop water demand associated with cool changes need to be used to catch up and refill the soil.

In this case study, the grower did a good job of keeping the water up to the crop through early January with both IrriSAT and soil moisture sensors showing irrigation meeting crop water demands.

In mid-January 20 mm of rain fell, increasing soil moisture to above field capacity (Figure 3). Following the rain, the grower did not restart irrigation for seven days during which time, the daily maximum temperature was over 35°C and the crop needed 43 mm of water. This drove the soil moisture to its lowest levels.

> The low soil moisture levels during the sensitive tuber bulking up stage would have reduced overall yield. We estimate that yield losses of 10% resulted from the delayed restart of irrigation after the rain. Across the half pivot the yield losses could have been between $12,600 and $17,900.

Maturation and vine senescence

The crop had recovered from the water stress by the 28 January (Figure 1) but the water balance remained in deficit until harvest (15 February) because of the earlier water stress period described above (Figure 5). Tuber quality was excellent across all areas of the paddock. Yields were lower than expected, probably due to the water stress. No disease issues and no hollow heart was detected.

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The final outcome: This case study shows how the **IrriSAT** app used with soil moisture sensors can provide growers and irrigation managers with essential information about irrigation needs and actual crop water use. The irrigation was well done for the most part of the season, with one underwatering issue after a rainfall event mid-January 2020. This caused the crop to go into water stress during the critical tuber bulking stage, which was likely to have caused premature vine die off in marginal areas of the pivot and reduced overall yield.

Tech box

Potato crop: The variety "Snowden" was planted on 1 November 2019 in a field near Cowra NSW with centre pivot irrigation. The grower irrigated as usual with the two tools used to monitor the soil and crop water use, but not directly used to schedule irrigation. The crop was harvested on 19 February and yield measured from the pivot. In the week before commercial harvest, two plots were hand dug to estimate yield in the area monitored with the soil moisture sensors. Monitoring focused only on the west half of the pivot as the east half was planted at a later date (Figure 1). Potato yield was assessed pre-harvest in zones exhibiting different growth patterns. Harvest of the potatoes started on 19 February 2020.

Soil sensors: A wide range of soil moisture sensors are available. For this case study, soil moisture levels were monitoring using Wildeye units (soil sensors at 20 cm and 50 cm to measure volumetric soil water content, %) installed in either the good or poor area under the pivot. Soil moisture was monitored every 30 minutes from 26 November 2019, when potatoes were in the very early vegetative stage, until harvest on the 19 February at two locations under the 14 ha pivot. Data is sent back to the cloud allowing easy access to the information.

IrriSAT: IrriSAT is a free weather-based system for monitoring crop water use. IrriSAT uses weather information (temperature, wind, humidity) to calculate crop water loss (evapotranspiration) for a reference grass crop (ET_o). Importantly, IrriSAT uses satellite imagery to get a measure of ***your*** actual crop growth and calculates a crop factor (K_c) which tracks your crop development over the season for the whole paddock. This is obtained from the Normalised Difference Vegetation Index (NDVI) data which is then converted to a crop factor.

IrriSAT then estimates daily crop water use (ET_c) by multiplying the reference evapotranspiration by the crop coefficient ($ET_c = K_c \times ET_o$). A simple soil water balance is available which keeps account of crop water use, rainfall and irrigation.