Using C-Probes: Irrigation decisions from the plants' perspective

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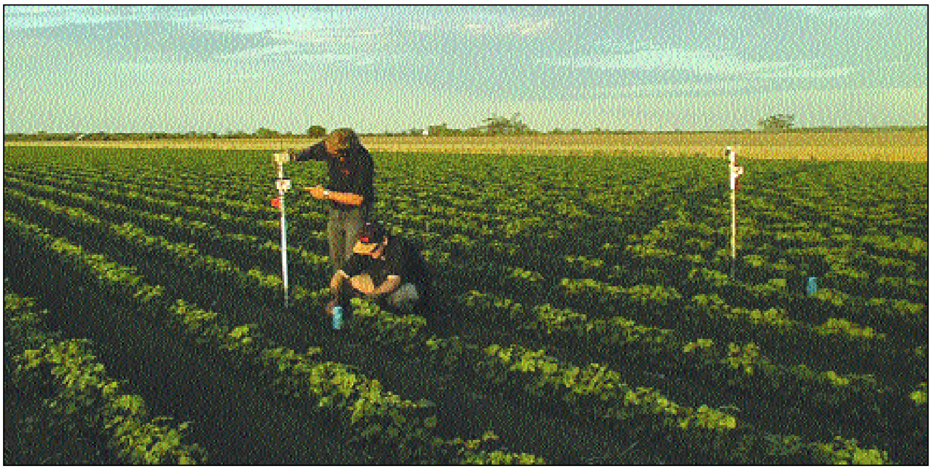
The neutron probe found its place in the cotton industry throughout the 80s and 90s, bringing with it a quantum leap in irrigation scheduling and yield. The next major step forward in irrigation management is via continuous soil moisture monitoring using capacitance probes.

The combination of continuous soil moisture measurement with remote telemetry systems has allowed cotton growers to make the next major step in yield and profitability. But capacitance probes aren't neutron probes and to take advantage of this technology requires a shift in irrigation scheduling practices. It is now possible to view irrigation from the plants' perspective.



Checking a C-Probe installation at Auscott, Moree.

Let the plant do the talking — it's all in the shape of the graph

Continuous soil moisture monitoring shows such detail that you can watch the plant 'drinking' each day. The characteristic stepping highlights diurnal plant water use, and this can be seen at multiple depths in the root zone.

In this way, not only can we see how much water is being used, but also from where it is being used and how active roots are at different depths. If data from all of these sensors is summed then it is possible to look at total plant water use on a daily basis.

The key paradigm shift in moving to continuous soil moisture monitoring is to let the plant do the talking. It is clearly evident in soils that are prone to water logging, that greater water use is achieved after the onset of stress than straight after an irrigation event.

If irrigation can be applied at short notice, then it is best to hold off until the point where the slope of the curve flattens off to be less than the average daily water use after an irrigation event.

Deficits are a dirty word

Allowable deficits are the universal language for irrigation scheduling in the cotton industry thanks to the good work done with the neutron probe. But technology has moved on and C-Probes should not be used in the same way.

The ability to watch the plant drink means that we can be more flexible and reactive to irrigation scheduling, especially once the plant reaches the onset of moisture stress. The highly sensitive nature of capacitance probes actually makes them difficult to calibrate and so it is best to not pay too much attention to the numbers in any case.

Previously it wasn't possible or practical to get enough readings at the end of a cycle to measure the slow down in water use or really understand the plant response at the end of an irrigation cycle. Since the plant begins to look visibly stressed during this period, the natural reaction is to irrigate and use this point (onset of stress) as the refill point.

It is only once you begin to measure what is actually happening that it becomes apparent that waterlogging can be a bigger problem which is exacerbated by watering too early through conservative allowable deficits. Allowable deficits per se are not the problem — it is being able to know in advance how to vary them for different varieties and seasons. Why try and second-guess what the plant needs when it can now tell you?

Continuous soil moisture monitoring with remote telemetry is not just convenient, it will actually teach you how well the plant is able to keep holding on. And the ability to see this in real time greatly assists managing a crop that is getting dry.

Attention can be given to those fields that are suffering moisture stress so that they can be carefully observed in the field. The confidence to delay irrigating a little longer is gained from watching the plant drink on the graph and in the field.

Different varieties react differently depending on season, soil type and other factors. Refill points also change as the root system grows throughout the season and so how do you know that you are using the most appropriate refill point?

The ability to listen to the crop and react to it takes out the guesswork and means that we can toss out the numbers and start looking at the shape of the water use curve. This is a change in attitude which may take some getting used to, but it is the secret to effective use of C-Probes. It is the common experience to dig more holes after installing C-Probes than before, in order to gain trust in the sensor and re-calibrate the thinking.

The first irrigation

The first irrigation is critical to setting up the root zone for the remainder of the season, yet it is also the hardest to get right. But the ability to very accurately visualise root activity at different depths means that it is possible to watch the soil sequentially dry out as the root system grows and estimate

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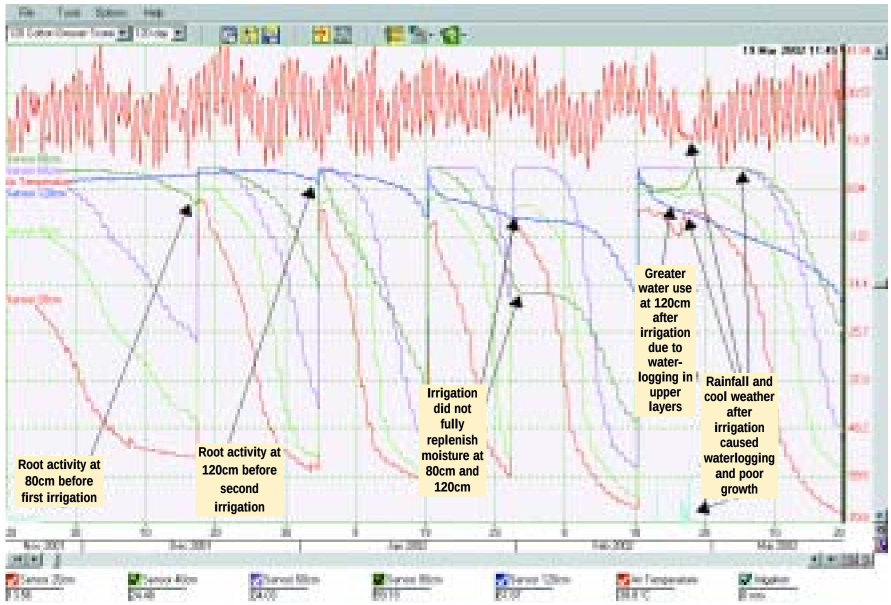
FIGURE 1: Bourke field



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the amount of stress the plant is under.

By watching water use in real time, you can have confidence in pushing the crop pretty hard to get its roots down a desired depth, but still have confidence that it is alive and drinking. If the weather is cool, then it is often possible to delay the first irrigation by some considerable time and see that the root growth into moist soil can keep up with evaporative demand.

Extending the irrigation interval

If the irrigation interval can be stretched by two days per cycle, this may equate to 10–12 days over a season and effectively cut out an irrigation. Apart from the water, labour and pumping costs saved, it also increases the chance of rain falling on dry ground by about 15–20 per cent.

Conversely, having fewer irrigations decreases the chance of rain falling on recently irrigated fields causing extended waterlogging. A longer irrigation interval may also mean that a reduced capacity in irrigation infrastructure is required as there will be more time available to irrigate all fields.

Irrigation scheduling — C-Probe repeatability is the key

The third, fourth and fifth and subsequent irrigations are easily forecast with continuous monitoring using the principle of hindsight. C-Probes produce highly repeatable results and you can be extremely confident that when the graph reaches the level at any individual depth, or summed, the soil moisture is at the same level.

It is evident that once the roots are established the onset of stress at each depth occurs at the same moisture content (Figure 1). For established root systems it is easy to base the upcoming irrigation on a refill point established from the previous irrigation.

Assuming that the weather conditions are the same, then it is also possible to forecast the next irrigation date, simply by counting up the number of days (seen as steps on the graph) from an equivalent point on the summed graph for the previous cycle (Figure 3).

FIGURE 2: Wyadrigah field 17 2000–01 (yield 7.5 bales per hectare)

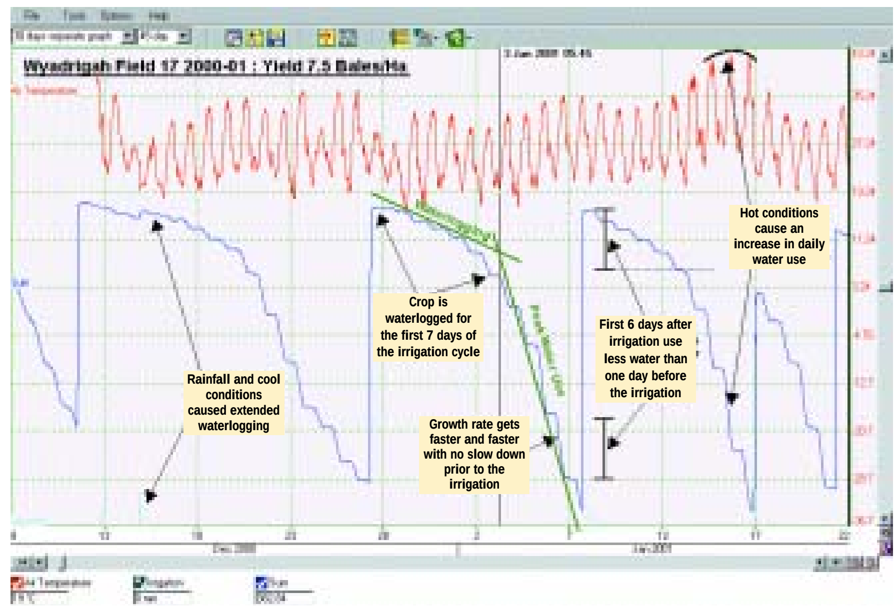
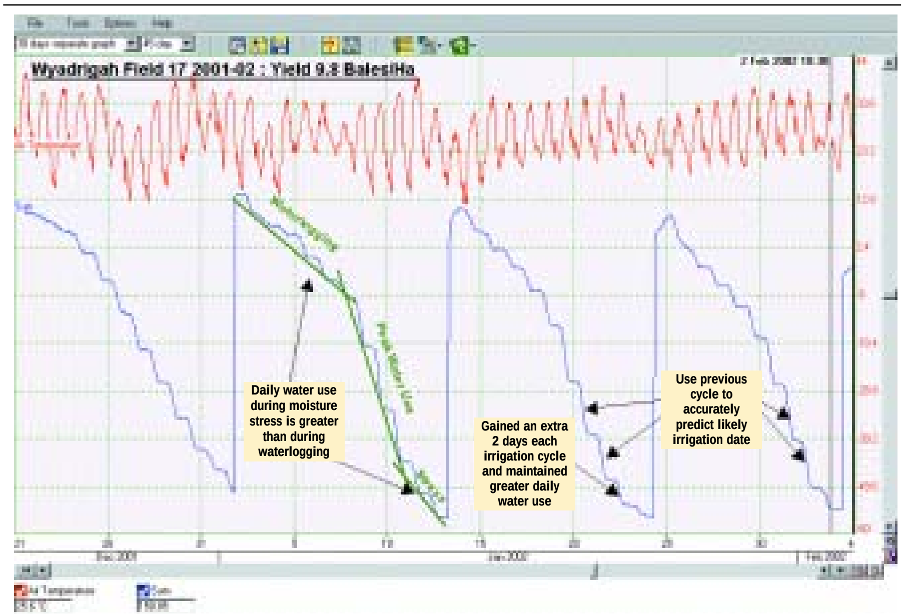


FIGURE 3: Wyadrigah field 17 2001–02 (yield 9.8 bales per hectare)



Application of foliar fertilisers and other systemic chemicals

Fertilisers and other systemic chemicals will have the greatest uptake and/or effect when the plant is rapidly transpiring. But the standard practice with application of foliar fertilisers is to apply them during the waterlogging period, straight after an irrigation event.

Based on the daily water use, it is clearly evident that in many cases the plant is not very photosynthetically active during this period and there is a significant risk that the fertiliser or chemical may not be fully taken up. Given that we now have a tool for estimating plant photosynthetic activity, the application of foliar fertilisers, Pix and other systemic chemicals can be timed for periods of greatest growth activity.

Risk management

The ability to listen to the crop adds a whole new dimension to managing new varieties, new irrigation fields or new agronomic practices. Agronomic management can now become more responsive rather than prescriptive, enabling irrigators and agronomists to view growth in real time and adapt to changing conditions to ensure that yield and profitability are maximised every year. This reduces production risk and helps growers to become more profitable and sustainable.

C-Probes are just a tool

While C-Probes are very effective at determining an irrigation schedule, it should be remembered that this is only for one part of the field. If the probe is poorly sited then the information could be very misleading. For this reason, selecting the right monitoring site within the field is of paramount importance and this is best done by utilising spatial monitoring such as yield mapping, EM surveys, vigour maps and any other spatial information at hand.

Remote telemetry allows the probe to be placed virtually anywhere in the field and a site should be selected that represents the most profitable section of the field (which may not necessarily be the highest yielding area). C-Probes are just another tool in the tool box and they will benefit enormously from spatial monitoring, just as spatial monitoring will benefit from detailed site specific information.

CASE STUDY 1

In 2001–02, cotton was grown at Bourke with extremely limited water supplies. As a result, the crops were pushed much harder than would normally be considered, and this produced some surprising results. By holding off the first irrigation for as long as possible, it was evident that the roots had penetrated to 80 cm.

This early root development was assisted by some relatively mild weather. By the time of the second irrigation, the roots had penetrated to 120 cm and had effectively given the plant access to approximately 40–50 per cent more stored soil moisture than a root system that only reached 80 cm, as might normally be the case. This greater effective reservoir allowed the crop to perform well under continued stress and yield a 7.5 bale per hectare crop of Pima S7.

It should also be noted that the larger and deeper root system allowed the plants to better handle the waterlogging event caused by 125 mm of rain after the final irrigation. It is clearly evident in Figure 1 that the plants are drawing moisture from 120 cm when there is no water use at shallower levels. This is presumably because the soil is less waterlogged at this depth.

CASE STUDY 2: WAITING FOR THE ONSET OF STRESS

C-Probes were installed at 'Wyadrigah', Mungindi in 2000–01 and irrigation was carried out as per normal practice, learned from several years of neutron probe readings. Essentially irrigations were timed so as to not allow the plant to move into visible moisture stress (Figure 2).

After reviewing the data at the end of the season, it was suggested that one simple change to irrigation practices be implemented and that was to watch for the slow down in water use at the end of the irrigation cycle prior to irrigating (Figure 3).

The rule of thumb was to wait until the daily water use during moisture stress was roughly equivalent to the daily water use observed during waterlogging. This one management change resulted in a yield increase of 30 per cent and took the yield of this field from roughly equal to the district average to 1.2 bales per hectare above it. This yield increase was achieved in back to back cotton grown in the same field. Approximately $5000 worth of equipment produced an additional 114 bales of cotton from 95 hectares.

C-PROBE COST BENEFIT

- Hardware cost = $4000–$4300 per site (approx);
- Software subscription, installation, running costs = $300 per site per season (approx)
- One probe per 100 hectares = $43 per hectare capital and $3 per hectare running cost;
- To pay off in one year, a 1.1 per cent increase in yield is needed or less than 0.1 bale per hectare;
- To pay off over three years, a 0.4 per cent increase in yield is needed;
- Waterlogging costs 15 kg lint per hectare per day = $30.60 per hectare per day or 0.8 per cent total yield per day.
- Save two days water logging and you have 100 per cent return on investment. Save three days and you have made money in year one.