



On farm benefits of Canopy Temperature Sensors (CTS)

A grower perspective after four seasons

MACQUARIE VALLEY

Grower: Stewart Denston is an experienced cotton grower who has been trialling canopy temperature sensors (CTS) for the Macquarie CGA since the 2014/15 season. The Denston's have a family farming enterprise that is comprised of three separate farms. They irrigate from Burrendong Dam via the Macquarie River with a 7-day water order lag time. These are farms set up for irrigation, broadacre crops, and grazing.

An interview was conducted with Stewart Denston on the 2nd August 2018 by Amanda Thomas REO in the Macquarie Valley. Amanda has been facilitating the trial work with CTS in the Valley for the last 4 seasons.

In the first year of the trials (2014/2015), we had five growers participate in the trial, of which Stewart was one of them. The following two seasons we extended it across eight farms, all with different soil types and irrigation systems. The final season saw Stewart adopt the CTS technology himself, and put a sensor in his heavy and lighter soils.

SD (Stewart Denston): We have participated in the trial work with CTS for the past four years and over that time we have seen some varied results.



Canopy Temperature Sensor on farm.

In 2014/2015 there was a correlation between yield and accumulated stress hours over 28°C which is what prompted us as a group to continue with our trial work to determine if it could become a tool in conjunction with soil moisture deficits to schedule our irrigations.

AT (Amanda Thomas): The first year we hired the sensor from CSIRO. We had some difficulty getting them, working as we needed to retrofit external aerials to pick up our patchy 3G signals. It was hard

to keep the ball rolling as there were varying degrees of familiarity with the equipment. Also, the platform on which the data was presented was not related to any other moisture information the growers had. We did not want to see this data in isolation but in conjunction with our C probe and weather station data.

The following season we used a commercial partner, Brian Thomson from Porosity Agricultural Services. This enabled us to involve more growers, all be on the same web-based platform, and provided some assistance in installing and maintaining the sensors and probes. The trial was set up so that Growers, the MCGA, Grass Roots Grants and Porosity would all contribute financially, so we all had some “buy in”. The 2017/2018 and 2018/2019 seasons were funded by Stewart Denston and the MCGA and we were just looking at two sensors in different soil types on Stew’s farm.

SD: The trial funding got us access to the equipment for the first three years, then we did it ourselves for the last season.

Q: What are the benefits?

SD: It’s a reference point when temps are increasing to try and understand how it’s impacting the soil moisture deficit at key growth stages in the crop.

It’s also a quantifiable reference against stress events – ie in dry hot situations the canopy can and will cool itself efficiently if it has adequate moisture and the irrigation intervals are timed well (we saw this many times in the trial). However, in times of high humidity the crop will struggle to cool itself (saw this many times as well). In one of the four years, we had some bad cavitation in crop which was directly related to the crops inability to cool itself. In the heavy grey clay, we saw it the most. It just could not draw the moisture out of the soil fast enough to cool the plant.

AT: Our shared platform, with the 8 participants on different soil types and irrigation systems, allowed



Canopy Temperature Sensor in field.

us to see each other’s irrigation intervals, C Probe information and accumulated stress hours. It was a great learning tool. The consultants reported that often this data would encourage other growers to water on tighter intervals in some cases. Being able to compare what different canopies were doing in the same weather situations allowed us to learn that it’s not just about temperature, but what is in the bucket, that impacts the crops ability to cool itself. We also had drip irrigation in the trial as a benchmark. It was watered daily and did not have a humid environment like the overhead and furrow fields.

Q. Has CTS changed the way you schedule your irrigations?

SD: Initially we thought CTS would not have a fit as a retrospective tool. We thought it would be a predictive tool and be used for scheduling forward. We were looking at the last interval a lot, and the stress hours



CTS field day at “Miegunyah” in 2015/2016 season – Brian Thomson of “Porosity Ag Services”.

or lack of stress hours to decide on the next interval. We are not just sticking to the old rule of thumb or set days but changing it on the run, based on the previous interval. With CTS in the toolbox we can look at the crop during that interval and tell if it’s “happy” with that interval and confirm this by the crops development.

How we use it changed over the four years. We were hoping it would be a one stop shop that would tell us when to water and a new way of scheduling, but we did not use it that way. We used it more to evaluate the previous interval or two and respond on the run using the same deficit, but tweaking the water a day early or a day later based on how the canopy is handling those temps.

AT: A great example of this was in the 2017/2018 season. Stew called me and said “we had a low reading going on with CTS, can you go check it out (I am away)”. It was three days out from an irrigation and temps were getting pretty hot, he was expecting to be accumulating stress hours like the other crops on the platform. When I walked into that crop the chill in the air was evident and the leaves of the canopy were cool to touch, so it was doing its job very well in hot dry conditions.

Q. What are some other key learnings?

SD: Soil types are a big thing.

Different soil types denote different canopy styles, and they behave differently in terms of the canopy temps. Heavy soil types can be slower growing and stress after an irrigation. I guess it’s the difference in the bulk density for a start, and then the root development or lack of, in some soils versus others. The size/style of the canopy can determine how they handle the stress. This trial has shown us this over the seasons. We had some double skip in the trial, and it was accumulating lots of stress hours early in the season, then at the end it was one of the cooler crops.

Q: Does heat stress (accumulated hours) relate to yield?

SD: Over three different seasons we saw three different things, which is what has thrown us really. Year 1, we saw a direct correlation between yield i.e lower stress hours, higher yield, as each season went on we did not see that pattern again, but each season had a different “ah ha” moment, so we were not game

to rely on that one pattern the following season. (see our reports for more details) <https://cottoninfo.com.au/>

In the 2018/2019 season I believe the timing of the first two irrigation's impacted on our yield. The plant appeared to be happy whilst racing through its growth stages and as a result we stuck to full normal intervals eg 50 days for first and then 20 days or near enough for the second one. It got very hot around this time and we may have capped our potential right at that point, this is based on a bit of hindsight and talking to some other growers that tightened right up from the start.

Q: Do we fully understand where research is heading?

AT: No I don't think we have all the info we need to work out where the research is going, and so when we talk about CTS, we are talking about how we have used it over the past four years. We are aware that there is an algorithm that will allow this tool to have much more potential but at this point we don't think we fully understand that well enough. Our valley has irrigators of all shapes and forms and while some are bore irrigators and can be very responsive, some order water 14 days in advance and need to take it when it comes especially in dry years.

SD: This tool fits perfectly for fine tuning things on the run, for a farm that has and can use adequate water storage and reliable water source. However, in some (most years) water is coming hand to mouth, where we have up to a 14 day lead time. From what we can see, it does have limited uses for a scheduling type tool.

SD: The other thing we have not had in the last four years is a cooler wet season. The seasons where we had CTS installed have all been above average day degrees (DD). We are keen to see how this technology goes in cooler years.

We don't know the potential of delaying water in cooler years, particularly on our heavy soils in the Macquarie

where our grey clays have a high bulk density. These soils can destroy yield potential if you water too early or before rain in these years.

Q: Topics for future research?

AT: We would love to get some further analysis done on the data we collected, as the seasons have been very different in terms of yield particularly the 2016/2017 season in comparison to the 2017/2018 season. We did not apply for funding in the 2017/2018 season and so Stew just had two CTS in each of his main soil types. The yield difference on Stew's farm was over 3 bales more in the 2017/2018 season on average. We know that one of the main differences was the amount of cold and heat shock days (2 x higher on both accounts) but we want to find out more about how and when this affects the plants. We have weather station data and would love to get into the "Machine Learning" in relation to the last season.

SD: As a manager, it would be good to know if our crops are tracking okay or is this season not going to have the potential, i.e. I should not purchase that extra water and be throwing the kitchen sink at it. We want to know 'when and where' in the season we accumulate stress hours ie at flowering and boll fill, and what impact that has on yield potential. We have the hindsight and data on three very different seasons and three very different accumulations of day degrees.

QUESTIONS

1. Are there times we need to look closer and do our best to minimise the stress accumulation and are there times when we can push it out?
2. How much do night temps affect our overall yield potential and when are the danger periods? Can CTS help us monitor this?
3. Can we get to the point where we get X amount of stress hours at XX of crop development and know where we are sitting?

Q: Can CTS lead to more crop per drop?

SD: The old systems of being a day early if you were a day late last interval is not where we want to be. Let's get more technical and see how many hours we accumulated in the previous interval; use the forecasting to see what's ahead in the next 7 days and if it will be hotter, see if humidity is flaring up, and night temps are not dropping down. Then we know its potentially pointing towards a stress event, using the last interval data and the short term forecast to see potential train wrecks and be able to try and mitigate them.

Q: How do you think CTS can benefit your farming system (in a quantitative and or qualitative sense)?

SD: A benefit is having something other than soil moisture data, which tells us very little about the plant.

It only deals with the soil moisture deficit, and the big thing we have taken from the four-year trial period using CTS, is that the canopy is happy sometimes and sometimes it's not. That can surprise you, as it's not just about temperature and watering as we used to think.

I feel the net benefit is not fully known yet, but we are getting closer to finding it out. By highlighting when and where the stress events are occurring and taking what has happened in the last two seasons – eg boll numbers were similar for both seasons, however our yields were 3 bales/ha different. We can use our powers of deduction and work out some things. We know that it's boll size, it's boll weights, it's seed density, but it would be nice to compare the accumulation of stress hours with the weather station data and drill down into when are those critical times and see if there is a relationship there. We have data for a number of sites across the valley and some of them had hotter canopies all season than others, is it soil type or something else?

Uniform crop at "Miegunyah".



Where we have not gone yet is looking at boll numbers. When we crunched the data for boll numbers we thought that would give us a certain outcome. We kept sinking inputs into the 2016/2017 crop and we were more than disappointed when we put the pickers in and across most of the growing regions it was not what we were hoping. Does it tell us that it's environmental when more than 1 or 2 regions are down on what we would expect?

However, in the 2017/2018 season when we had the same boll numbers, our lesson from last season was strong in our minds so we did not expect to get the yields that we got (records were broken and farm averages the best they have ever been in the Macquarie). However, it does not seem that this was the case in all regions? We actually used less water and produced more lint than the season before. The canopy on the 2016/2017 was a beast of thing and did not fruit until around 10 nodes and did not produce the bottom crop that we did the 2017/2018 season. Was it just a case of reduced cold shock and insect pressure early on that was the difference or was it how and when the heat stress came?

RECAP ON THE BENEFITS OF CTS TO OUR COTTON SYSTEMS

1. Help us monitor the crucial periods and give us the ability to better manage these fields to reduce stress (both heat and moisture stress), ie bring irrigation forward when it's hot or delay when it's not.
2. Help us to quantify our potential for our crops during key growth stages in the season to give us better yield estimates/potential.
3. Use the information above to be better managers, reduce the risk periods, provide more accurate crop data sets which can lead to better marketing decisions, water use efficiency, and nutrient input efficiencies.
4. Sharing a platform with other growers and seeing what others are doing and how it impacts the canopy temps.

WISH LIST

Better information to be able to segment the season, figure out critical stress levels and times, and do this for different soil types, as this is where we can impact profitability on our farms. The two seasons were equally as hard to manage but to see yield differences of 3 bales/ha we know it's worth it.



Acknowledgements

We would like to thank Stew Denston for his commitment to the trial work across the Macquarie Valley as well as the growers who have participated over the years, CRDC for the contributions via grass roots grants, CottonInfo and the Macquarie Cotton Growers Association who have contributed to the trial work over the past 4 years. We would also like to thank Porosity Ag Services, CSIRO.