Australian Government
Cotton Research and Development Corporation

CottonInfo Extension Activity REPORT

Part 1 - Summary Details

Please use your TAB key to complete Parts 1 & 2.

CRDC Project Number: **CSD 1701**

Project Title: Season Benchmarking with Canopy Temperature Sensors

Project Commencement Date: 1/12/2016 **Project Completion Date:** 1/06/2018

Part 2 – Contact Details

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Part 3 – Final Report

Background

The project objective is to summarise and extend the learnings and experience that growers have gained after four seasons of using Canopy Temperature Sensors in the Macquarie Valley. The Macquarie growers saw potential in Canopy Temperature Sensors (CTS) as another tool to help schedule irrigations to maximise crop production. They used them over four seasons from 2015 to 2018. Porosity Services was contracted to supply the CTS, and each site was integrated with soil moisture probes and weather stations and provide a web-viewing platform for all MCGA members. CSIRO provided the CTS sensors in 2016 (see appendix 5 for trial details), and then from 2016, 17 & 18, Porosity Services was contracted to supply the CTS, and each site was integrated with soil moisture probes and weather stations and provide a web-viewing platform for all MCGA members. To finalise this project our objective is to share the learnings with the whole industry.

Objectives

1. *Increased understanding of how CTS is used in cotton production systems.*
2. *To better understand the critical levels of canopy temperatures and soil moisture deficits that impact crop production.*
3. *Share learnings with other growers and researchers.*
4. *Provide feedback to the research community of the "on farm "benefits that growers in the Macquarie Valley have gained from using CTS.*
5. *Capture the key learnings from four years of using the CTS*
6. *Help identify challenges to the adoption of the CTS based on grower experiences.*

The project objective of increasing understanding of CTS in cotton production systems was achieved by using the technology on farm. The growers were extended information during the season on CTS to further understand how stress events affect cotton growth. A case study that captures the grower experiences over the past four seasons has been produced and can be used by researchers to gain an understanding of how the growers are using the technology and what benefits they are seeing at a farm level. It also shares the key learnings that the cotton growers and the service provider gained over a four-year period (Appendix 2).

We can see from the Porosity website metrics (Appendix 1) for the 16/17 season that growers were viewing the data from other sites as well as their own. It became apparent that growers were using this shared web viewing platform as another tool. They were looking at the effects on canopy temperature from differing timings of irrigation. Incorporating the soil moisture probes in the information platform meant that other growers could see refill points and irrigation schedules for their fields as well as other growers on the platform. The on-farm weather stations also captured rainfall and weather conditions such as relative humidity. These technologies together gave us a whole system scenario that allowed us to see much more than one singularly.

As per objective 5, the participants wanted to capture the experience they have gained and nominated Stewart Denston for the case study. He has been using the technology for four seasons and took part in an interview with Amanda Thomas (CottonInfo) to identify what he had learnt and how he sees the technology being of benefit to farming systems in the future. The key learnings and practical experience over the past four seasons will be extracted from our previous trial work as well as the interview conducted that will form a case study. From this case study we will extract the real-life challenges to the adoption of the CTS by growers and agronomists.

Activities

The activities conducted to achieve the objectives were:

- CTS, soil moisture probes, in-crop temp sensors (which monitor ambient temp at 2 meters above the canopy), and 2 professional grade Automatic Weather Stations were installed on 7 sites in the 2016/17 season and 2 sites in the 2017/18 season.
- Access to the web-viewing platform via Porosity Services website hosted all sensors and weather station data. This was available to all growers via registration system.
- Two on-farm demonstrations that showcased the trials were held at "Quondong" near Trangie and the other "Meigunyah" at Gin Gin. Brian Thomson of Porosity Services presented information on CTS at both in field demonstrations (see appendix 3 for further details).
- A case study was developed that has a strong grower focus addressing the benefits and the gaps in understanding that we are left with after four years of using CTS on farm.

This has been done in the form of an interview/case study (Appendix 2) There is also an audio copy of the interview available.

- Provide feedback to the research community of the current benefits growers have gained from the technology and how it would fit into integrated irrigation management. (Appendix 2).
- Updates and posts on the Macquarie Cotton Grower Facebook page over the 3-year period.
- A 30-minute interview with grower Stewart Denston and CottonInfo REO Amanda Thomas is located on Macquarie Cotton Growers Association website https://www.mcga.org.au/ and is available to all growers, consultants and researchers.

Outcomes

7. Describe how the project's outputs will contribute to the planned outcomes identified in the project application. Describe the planned outcomes achieved to date.

The planned outcome is to increase understanding of CTS technology and its fit as a scheduling tool and to provide a summary of how the growers used CTS in their decision-making processes when scheduling irrigations. Due to unforeseen circumstances, the trial aim was modified slightly to provide feedback to growers and the research community about the way in which growers use this technology and how they see it fitting into current farming systems.

The demonstration farms provided firsthand experience on installation, maintenance and how the information is displayed during the season. All Macquarie MCGA members had access to the data collected from the demonstration farms. This included canopy temperature, soil moisture and weather station information (rainfall, temperature and humidity). This allowed them to see real time data on a web based shared platform.

Growers where not only interested in their own data but also looking at others who had either just irrigated or were holding off and seeing what was happening with the CT in these situations. The shared information platform provided by Porosity Services was a benefit to growers that we did not anticipate in our planned outcomes. Incorporating the soil moisture probes in the information platform meant that other growers could see refill points and irrigation schedules for all the demonstration sites. The on-farm weather stations were able to capture any rainfall and relative humidity and key variables when looking to implement dynamic deficits (Brodrick 2016). Brian Thomson of Porosity Services was able to share information and knowledge with growers via in-season updates that showed the accumulated stress hours (for this project we used canopy temperature hours over 30°C). Any hours that were accumulated above this temp were considered stress hours. We used the 30°C based on information that we gained from the 2015/16 and 2016/17 seasons, as well as work by Coast and Brodrick (2016) in the 2014/2015 season (Appendix 5).

Outputs

To achieve the planned outcomes, we have produced the following outputs;

1. The 2014/2015 trial booklet available on the CottonInfo website pages (29 to 42) https://www.cottoninfo.com.au/sites/default/files/img/Booklet_2015.pdf
2. The 2015/16 Canopy temperature sensor trial booklet was produced and distributed to growers and consultants in both electronic and hard copies. It is also available on the CottonInfo website www.cottoninfo.com.au/regional-newsletters
3. Over the three seasons the trial included data from eight grower participants and two weather stations that were accessed by growers, contractors and broadacre farmers. We provided free access and it has become a great tool in the fight against spray drift in the valley. Figure 1 provides a summary of the weather station hits per day in the 2017/2018 season. It has been funded by the MCGA for the past three seasons and remains a legacy of the CTS trials.

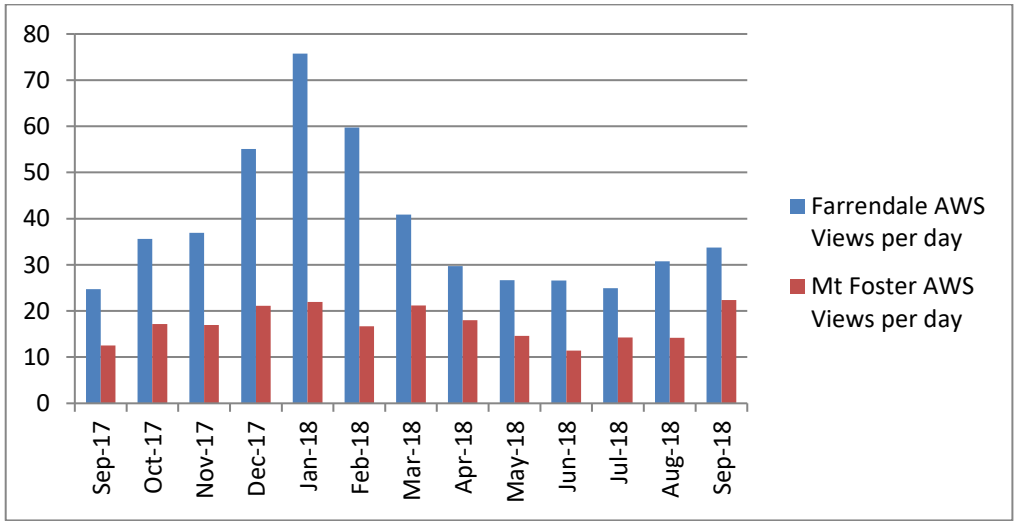


Figure 1: A summary of hits per day over the cotton growing season. (Source Porosity).

4. The "Growers perspective of using CTS in the Macquarie valley" case study (appendix 2) will be distributed to growers in the valley, it will also be available for any researchers or service providers.
5. Articles in regional newsletter by CottonInfo REO in the Macquarie Valley. Over the four seasons we covered many articles and the key findings from any on farm demonstrations (see appendix 3 for further information on the demonstrations)
6. Audio recording of the interview that was used to contribute to the case study, the aim is that this could be used by researchers and other growers to gain further perspective. This will be available via the Macquaire Cotton Growers Association Website https://www.mcga.org.au/

Conclusion

Although the project did require a variation due to unforeseen circumstances, we managed to capture what we have learned over the past four seasons. The trial incorporated CTS into an already extensive scheduling tool box and gave growers a supportive network to be able to discuss the findings with each other. Each season has presented a different set of challenges, however having collected data from all four seasons has helped to build an overall picture of where we see the research gaps and how growers would like to use this technology going forward. From the firsthand knowledge and experience by using the technology and seeing the data from three seasons the following conclusions were highlighted by the participants.

- Growers concluded they do not see CTS as stand-alone tool, but as part of an extensive tool box that incorporates things like capacitance probes, Irrisat forecasting, satellite imagery, and long and short-term weather forecasting.
- Of the eight growers who participated in the trial, two have begun using CTS on their farms after the trial. The two growers both only use one or two CTS in different soil types, they don't see it as something they would use in every field.
- Two of the growers stated that the sensors required too much in-field maintenance at a time when they are busy irrigating (sensors needed to be moved up 30cm above canopy every two weeks).
- The growers said that "not enough information is known on how a stressed canopy impacts WUE and yield".
- The growers liked that CTS got them thinking about another factor other than what was in the soil. One of the grower co-operators pointed out that we all tend to feel the leaves of the crop as we walk into it, which was something we did not think to do before using the CTS.
- The 'real farm' constraints such as water ordering lag times (10 days in some cases in our valley) can mean that the advantages that CTS could potentially provide are conditional depending on whether the grower had scheme, river or bore water access. In practice, when the grower has ordered the water and cannot change delivery date they cannot respond to CTS indications of ideal irrigation timing.
- One of consultants who was a part of the trial reported the 'shared web-based platform' as a great tool to get his grower to water his crop on time. "I just had to show him the field next door was 3°C cooler than his and he moved forward the irrigation" (Note this was a grower on bore water who had some flexibility over irrigation timings).

Key findings by Stewart Denston

Take home messages from the participation in the trials over the four seasons were as follows. (source: Stewart Denston "Miegunyah" grower case study Appendix 2)

- *"CTS helps you to know your soils and the impact this can have on the crops ability to cool itself. It's not just about looking at probe and water used, we need to know if the plant is happy or stressed." (Stewart Denston).*
- *CTS gives me a 'tangible' value on the crop's "happiness". By benchmarking my stress hours each season against others on the platform and comparing past seasons, I can*

retrospectively consider the last irrigation interval and see not only if it was using water but how many hours it was not in its "happy place". I can use that information to inform future irrigation intervals.

- *"It's a reference point when temps are increasing to try and understand how it's impacting your soil moisture deficit at key growth stages in the crop".*
- *"It's also a quantifiable reference against stress events – i.e. dry hot situations the canopy can and will cool itself efficiently if it has adequate moisture and irrigation intervals are timed well (I saw this many times in the trial). However, in times of high humidity the crop will struggle to cool itself (saw this many time as well").*
- *"In one of the four years, we had some bad cavitation in-crop and it was directly related to the crops inability to cool itself. We saw it mostly in the heavy grey clay, the plant just could not draw the moisture out of the soil fast enough to cool itself". (This is shown in Appendix 4). "This is a great example of the technologies complementing each other and providing a more comprehensive dataset to tell the story".*
- *CTS are not just 'set and forget' they need maintenance and adjusting in season, this could be a drawback to some growers.*

Research Questions – Interviews by participants raised the following questions

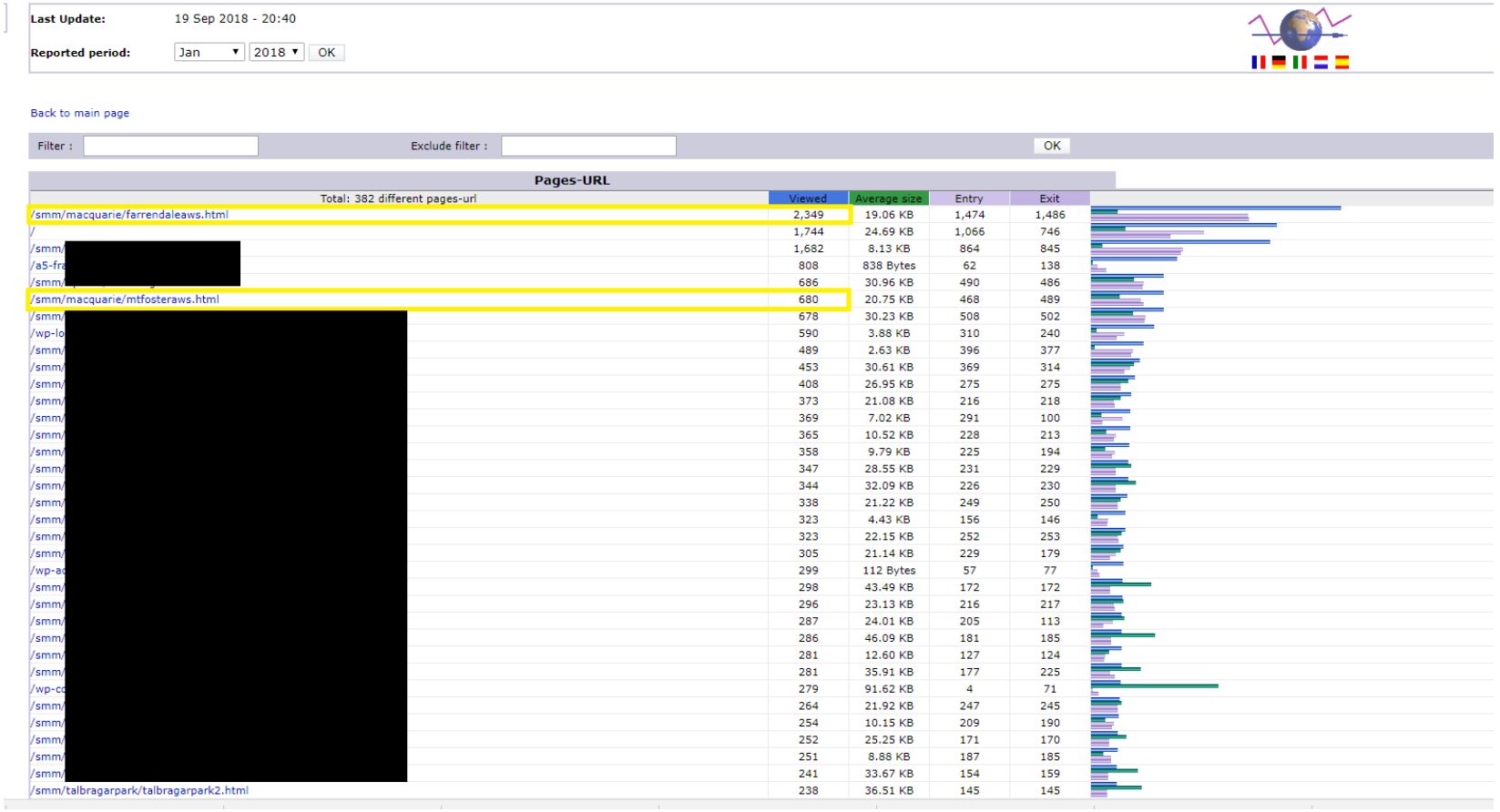
- When using CTS in conjunction with the 'algorithms" used by researchers do you see CTS as a stand-alone tool or is it still in conjunction with existing irrigation tools?
- How will the use of the Algorithm be of best fit in our current irrigation systems?
- Can CTS be used to predict and manage stress events? "Is it possible we get a snap shot of the season that has a red zone (do your best to avoid stress accumulation at this period) and an amber zone (best time for your pump to break down)?
- Have researchers identified how many accumulated stress hours in key physiological stages such as flowering and peak boll fill periods affect yield?
- We did not have a cooler wet year in the trial period, so we have no idea how it would work in those years, but we do see they could be of significant advantage in providing the confidence to hold off irrigations to avoid water logging events from rain following an irrigation.

Extension Opportunities

This project will provide great opportunity to contribute to many extension networks.

1. The case study will be available via the CottonInfo and MCGA networks.
2. We also plan to do a podcast version of the interview that will be an alternative to the case study as you could listen to it on the tractor or in the car.
3. We are happy to share this with other CGA's who are interested in our story so far.
4. The participants have formed a network and many of them are using the technology on farms this season.
5. We are very keen to share our data with the research community and hear from them as to where the technology is heading.
6. The case study will be available on the CottonInfo and MCGA website.

APPENDIX 1: On-line platform used to share Canopy Temperature, Soil Moisture and Weather Station data



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Pages-URL

Total: 382 different pages-url	Viewed	Average size	Entry	Exit
/smm/macquarie/farrendaleaws.html	2,349	19.06 KB	1,474	1,486
/	1,744	24.69 KB	1,066	746
/smm/[redacted]	1,682	8.13 KB	864	845
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/smm/[redacted]	287	24.01 KB	205	113
/smm/[redacted]	286	46.09 KB	181	185
/smm/[redacted]	281	12.60 KB	127	124
/smm/[redacted]	281	35.91 KB	177	225
/wp-co[redacted]	279	91.62 KB	4	71
/smm/[redacted]	264	21.92 KB	247	245
/smm/[redacted]	254	10.15 KB	209	190
/smm/[redacted]	252	25.25 KB	171	170
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/smm/talbragarpark/talbragarpark2.html	238	36.51 KB	145	145

APPENDIX 2:

WHAT ARE THE BENEFITS OF USING CANOPY TEMPERATURE SENSORS (CTS) IN THE MACQUARIE VALLEY?

A grower perspective 4 seasons of CTS…….

Grower: Stewart Denston, of "Miegunyah" located North East of Trangie NSW. Stew is an experienced grower who came on board with our original trial in the Macquarie in the 2015/2016 season and has been using the technology for the past 4 seasons. He is manager of the family farm that is comprised of three separate farms and irrigates from the Macquarie river via Burrendong dam with a 7-day lag time. This farm has irrigation cotton enterprises as well as mixed broadacre farming and livestock.

This interview was conducted by Amanda Thomas CottonInfo REO in the Macquarie valley. Amanda has been facilitating the trial work with Canopy Temperature Sensors (CTS) in the Valley for the last 4 seasons. This interview was conducted on the 2nd of August 2018.

CTS technology was first trialled in the Macquarie during the 2014 / 2105 season, we had 5 growers participate in a grass roots grant funded trial and Stewart Denston was one of them. The next 2 seasons we ran the trial across 8 farms and different soil types and irrigation systems, we did this for 2 seasons, 2015/16 and 2016/17, they were also contributed to by the individual growers, the Macquarie Cotton Grower Association and grass roots grants funding by CRDC. Our last season was 2017/18, where Stew adopted the technology himself and put it on two different soil types on his farm.

The purpose of the interview is to capture our key learnings and pass this onto the research community as well as other interested growers. We hope to gain further direction and possibly align with projects that will help us to keep ground truthing the technology in the Macquarie Valley. We also hope to let commercial providers know what experiences we have gained and where the information gaps currently sit.

Stewart Denston (SD): We have participated in the trial work with Canopy Temperature Sensors (CTS) for the past 4 years and over that time we have seen some varied results. The first year there was a correlation between yield and accumulated stress hours over 30°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.

Amanda Thomas (AT): "The first year (2014/15) we hired the sensors from CSIRO. We found it difficult to get some of them working as we needed to retro fit external aerials to pick up our patchy 3G signals, it was hard to keep the ball rolling as we were not all that familiar with the equipment and the platform on which the data was presented was a bit clunky. We did not want to see this data in isolation but in conjunction with our C probe and weather station data".

The following season (2015/16) we used a commercial partner, Brian Thomson from Porosity services so that we could involve some more growers, and all be on the same web-based platform and have some assistance in installing and maintaining the sensors and probes. The trial was set up so that growers, the MCGA and Grass Roots Grants and Porosity would all contribute financially so we all had some buy-in to it.

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

Q: WHAT ARE THE BENEFITS?

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

It's also a quantifiable reference against stress events – i.e. dry hot situations the canopy can and will cool itself efficiently if it has adequate moisture and irrigation intervals are timed well (I saw this many times in the trial). However, in times of high humidity the crop will struggle to cool itself (saw this many time as well). In one of the four years, we had some bad cavitation in-crop, it was directly related to the crops inability to cool itself, and 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 was a great learning tool. We had eight participants on different soil types and irrigation systems where we could all see each other's irrigation intervals, c probe information and accumulated stress hours. The consultants reported that this information was the only thing that would get some growers to irrigate on time as they would show them their canopy temp, then the neighbour who irrigated on time and it was much cooler. Being able to compare what different canopies were doing in the same weather situations allowed us to learn that it is not just about temperature but what is in the bucket and things like Vapour Pressure Deficit (VPD) that impacts the crops ability to cool itself.

We also had drip irrigation in the trial as a benchmark as it was watered daily and did not have a "humid "environment like the overhead and furrow fields. In the 2015/2106 trial it remained below 35 accumulated stress hours for the season (above 30°C was our trigger point in this trial). Brian Thomson of Porosity has been able to provide some ananlysis of the season that we have captured with the CTS. (please see appendix 1 & 2 at end of this report.)

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 predicative and used for scheduling forward, but as we went on we were looking at the last interval a lot, and the stress hours 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 tool box we can look at the crop during that interval and tell if its happy with that interval and confirm this by the crop's development.***

How we use it sort of changed over the four years, we were hoping it would be a one stop shop that would tell us when to water and 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, by 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 occurred 2 years ago (15/18 season). Stew called me, and said "we have a dodgy reading going on with my CTS, can you go check it out " (He was sitting on Manly beach checking his crop). 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, but when I walked into that crop the chill in the air was evident and leaves of that canopy were cool to touch, so it was doing its job very well in hot dry conditions.

The benefit of having the soil probe data on the same platform was a great learning tool as we could see how what's going on above ground impact the plants ability to access moisture.

Q. WHAT ARE SOME OTHER KEY LEARNINGS?

SD: "Soil types are 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 starters and then the root development or lack of in some soils verses others. The size/style of the canopy can determine how they handle the stress. This trial has shown this over the four 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 season we saw three different things, which is what has thrown us really".

"Year 1, 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 but we were not game to rely on that the following season." (see our reports for more details)

"Year 2, the findings were that the canopy cooled itself more as air temps increased, we also found that there was a correlation between the amount of water being applied, and how well the canopy was cooling itself. We only found a weak correlation between Canopy Temperature and yield." (see 2015/2016 report for more details).

"In summary in the first year we got a direct correlation between accumulated hours of heat stress and yield. i.e. lower stress hours resulted in higher yield. We did not find this correlation again in the next 3 seasons. This meant we have been cautious about making assumption about the crop based <u>just</u> on canopy temperature."

Q: DO WE KNOW THE LATEST RESEARCH?

AT: In the Macquarie 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 talk 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 trial work is just a summary of our observations from the seasons and is anecdotal in nature.

While this trial has given our Macquarie growers first-hand experience with CTS's, I don't believe we are using them to their potential. CSIRO have developed algorithms, so we can better understand the number of stress hours a cotton crop can handle before yield is impacted. Once these become available through commercial providers the full potential of CTS technology might be realised.

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, but in some (most years) water is coming hand to mouth (meaning we have to take it when we can get from the river) , where we have up to a 14 day lead time, with this in mind 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 we have trials the CTS in have all been above average DD. We are keen to see how this technology goes in cooler years to have them in the mix a bit.

We don't know the potential of delaying water in cooler years, particularly on our heavy soils in the Macquarie, the grey clays with high BD, these soils can destroy yield potential if you water to early or before rain in these years.

Q; WHERE WOULD WE LIKE MORE RESEARCH/EXTENSION?

SD: We would love to get some analysis done on some of these years as the seasons have been very different in terms of yield particularly the 2016/2017 season in comparison to the 2017/2018 season.

AT: We did not apply for funding in the 2017/2018 season and so Stew has the two CTS in each of his main soil types. The yield difference on Stews 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 (two times higher on both accounts), we need 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 we discussed, as manager it would be good to know if our crops are tracking okay or is this season not going to have the potential - "ergo" Should I not purchase that extra water and be throwing the kitchen sink at it"??

We want to know 'when and where' we accumulated stress hours I.e. at flowering or boll fill and when it has the biggest impact on yield potential. We have the hind sight and data on three very different seasons and three very different accumulations of Day Degrees.

PLANT PHYSIOLOGY QUESTIONS THAT THE TRIALS HAVE RAISED:

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 effect our overall yield potential and when are the danger periods? Can CTS help us monitor this?***
3. ***Can we get the point where we get XX amount of stress hours at XX of crop development and know where we are sitting?***

SNAPSHOT OF WHERE WE SEE CTS TECHNOLOGY GOING

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 stress hours we accumulated in the previous interval and use the forecasting to see what's ahead in the next 7 days; if it will be hot and humid and night temps not dropping then we know its potentially pointing towards a stress event. I reckon we can use the last interval canopy temperature data and the short-term forecast to see potential train wrecks giving us time to try and mitigate them".

QUESTION: HOW DO YOU THINK CTS CAN BENEFIT YOUR FARMING SYSTEM (IN A QUANTATATIVE AND OR QUALITATIVE SENSE)?

SD. The benefit is having something other than soil moisture data, as that tells us very little about the plant, it only deals with the deficit, and the big thing we have taken from the four year trial period using CTS, is that the canopy is happy and sometimes it's not and that can surprise you as it's not just about temperature and water as we used to think.

SD: "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 – i.e. boll numbers, they were similar for both seasons, however our yields were 3 bales/ ha different (please see appendix 4). 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?"

"Where we have not gone yet is, maybe when we looked at boll numbers and crunched the numbers and we thought that would give us a certain outcome, so we did keep sinking inputs into that the 2016/2017 crop and we were more than disappointed when we put the pickers in. In fact, across most of the growing regions it was not what we were hoping. Does this tell us its environmental when more than 1 or 2 regions are down on what we would expect?" (please see appendix 4)

"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 did get in some cases (records have been 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 a 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), I.e. bring irrigation forward when it's hot or delay when it's not.

2. Help us to quantify the 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 period, more accurate crop data sets can lead to better marketing decisions, water use efficiency, nutrient input efficiencies.
4. Sharing a platform with other growers and seeing what others are doing and how it impacts the canopy temps was extremely useful.

OUR WISH LIST FOR RESEARCH DIRECTION

Better info 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 hard to manage but to see yield differences of 3 bales/ha we know it's worth it.

APPENDIX 3 : FIELD DAY SUMMARY SHEET (SOURCE: Amanda Thomas)

CSD 1701 REO appendix 3 .pdf

WHO WAS THERE AND WHY?

Stu, Jock and Harley Crawford were at their property "Bungarley" (where one of the CTS trial sites is located), to talk about the pro and cons of drip irrigation and how CTS fits in with their whole system.

Brian Thomson (Porosity Services) – to discuss the CTS trial that is under way for the 2016/17 cotton crop. He installed 7 × CTS sensors (commercially available brand instead of CSIRO's own), that communicate with soil moisture probes and Adcon NextG telemetry units, along with a network of weather stations & sensors that were geographically spread across the entire Macquarie Valley. In consultation with MCGA, Brian also setup a customised website to compare all the sensor data to make the information available to all growers in the region.

Dr Mike Bange, Dr Rose Brodrick and Dr Hiz Jamali were all on hand to talk about the results from CSIRO's work using the sensors in Australia over the past nine years.

Amanda Thomas (me) I guess I'm assistant project manager on this trial and will be responsible for getting the results out to the growers at the end of the trial.

Pic 1. Canopy temp sensor working in the crop.

DRIP IRRIGATION

Over the past seasons Stu Crawford has played around with different row spacing's on his drip irrigation. He places a strong emphasis on using capacitance probes and has tried a few other approaches to give him better handle on how much water the crop is using. Over many years Stu has developed a good set of operation guidelines that have a strong centre around good establishment. He likes to wet the soil quite well to start with as it will encourage the roots to explore beyond the drip tape, as he has seen years when the roots are bunched up around the tape. This season

Crawford's are growing the BG3746 variety and feel that it responds to pix well and is easy to manage.
Crawford's have a strong focus of achieving high yields in their systems and feel that drip is well suited to their soil type and gives them good control over how much water to deliver to the crop. They currently use 2 capacitance probes to look at the data daily to ensure they keep the profile close to field capacity and ensure the subsoil does not dry down. Stuart claimed that the probes gives them a high level of confidence in irrigation scheduling compared to the CTS data, which is relatively new and they are trying to work out how they can use the info to improve irrigation decisions further. Since drying the profile down as defoliation approaches, the CTS has shown the canopy heating up, so the data should show the deficit point where the canopy stops cooling itself efficiently, which may improve scheduling in future seasons.
Brian Thomson believes that one of the main benefits of having the CTS in the subsurface drip is that due to the field being kept at a constant optimum soil moisture level – it enables all the other CTS sites to have a "benchmark" with which to compare the data on a day by day and seasonal basis.
Dr Mike Bange stated that late season water stress was not as important as the time of defoliation when trying to specifically manage for quality, "you would have to defoliate with > 29% immature bolls not ready to have a significant impact on Micronaire" he said. It is a wise strategy to have the crop use the water in the profile in preparation for harvest. The irrigations that are most important are the ones in January and February as that is when the yield (in particular fibre length) is being determined.

CSIRO – A BRIEF HISTORY OF CTS

Monitoring how well a crop is cooling itself is nothing new in the world of farming, the technology in some form has been around for more than 50 years – such as using the back of your hand to sense how a plant is feeling. The new science behind CSIROs approach to using infrared temperature sensors that are measuring the leaf surface temperature, and with the knowledge of cotton's optimum plant temperature of 28°C as the basis for quantifying plant stress. Many biochemical responses go on in the plant and each of them have optimum temperatures (eg. photosynthesis, respiration) by measuring the accumulated hours above an optimum temperature of 28°C we can calculate the time that the plant is spending under stress conditions. Using continuous canopy temperature sensors may enable managers to minimise stress. Several trials have been conducted using the infrared temperature sensors and trying to work out how to schedule irrigations based on the number of hours above the optimum temp, and once this threshold is reached then the crop is watered.

A SUMMARY OF THE CTS TRIAL FOR 2017

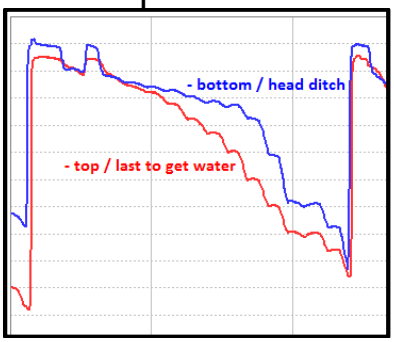
Once harvest is complete, the aim is to do a full analysis on the data from all sites to quantify the relationship between canopy temperature and yield & water efficiency. Initially we can see from the customised webpage, which displays a summary of all the CTS & weather station sites, that there are some big differences between how different irrigation strategies have resulted in different accumulated hours above the optimum, however until we can confirm the yields and water usage (ML/Ha and bales/ML) than we can only make assumptions. We hope to have this data analysed by July 2016, whereby a full report will be distributed to all MCGA members.
The challenge for the researchers and growers alike, is how do we take the best of all the technology available (not just probes) and make it a useful suite of tools that growers can use, and incorporate into their current scheduling practices?

Pic 2. Growers who attended the field day chatting with Brian about the trial.

Porosity Services, Agronomic Business Solutions & Cotton Info
Invite you to a brief and informative:

Crop Walk & Inspection

- **Bankless Irrigation**: check latest setup & layout
- **Using sensors**: helps adapt to new irrigation system
  - soil moisture probes
  - canopy temp sensors
- **Waterlogging**: Is that waterlogging we see on the probes? Boll counts will quantify if there is any difference between "bottom head ditch" & "top end":



WHERE: "Miegunyah", Trangie
WHEN: Thursday 5th February 2015
WHAT TIME: 10am sharp till 11am

For more information, please call Brian Thomson, Porosity Services - 0418 849161Stu Denston for directions on 0427007794

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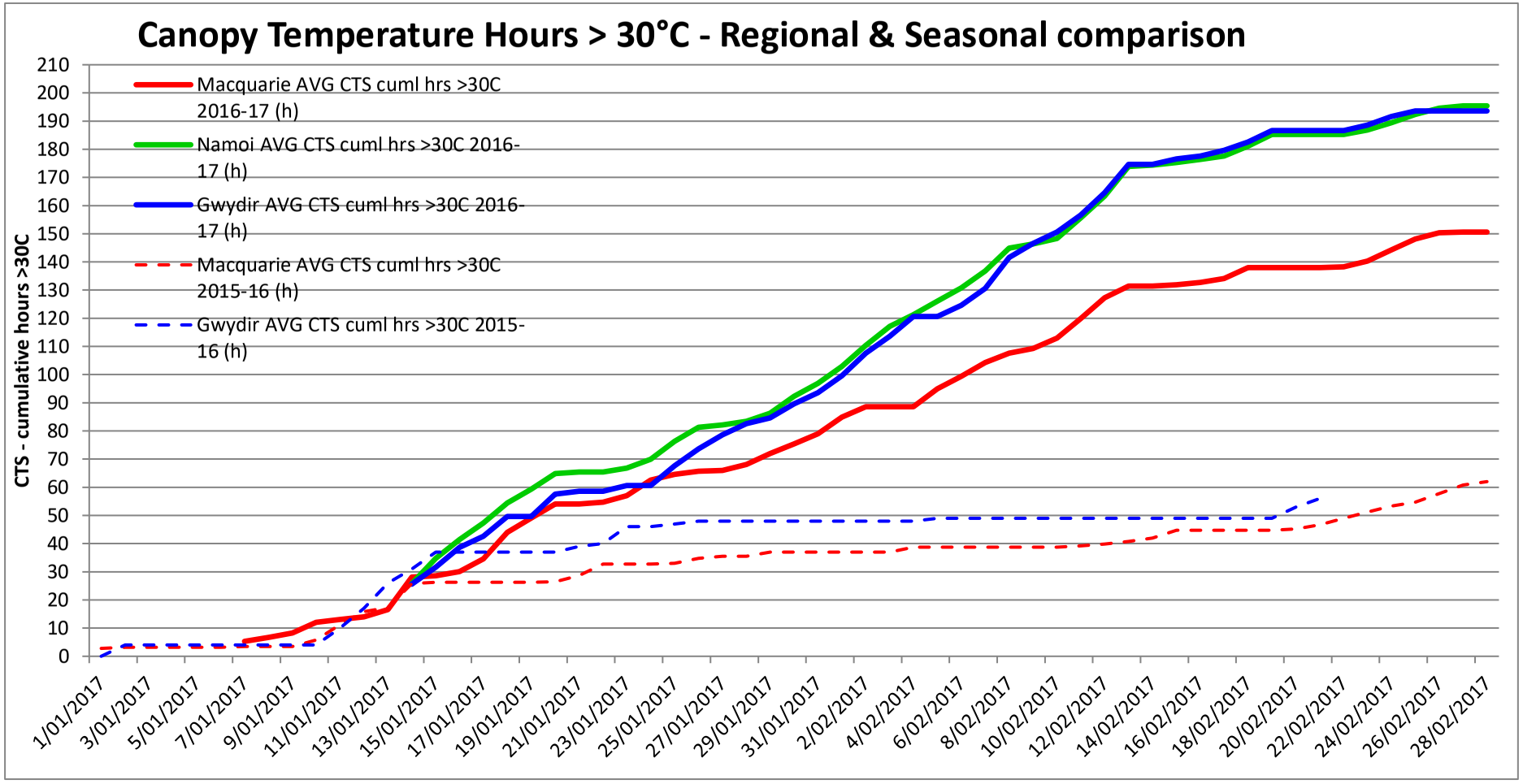
Appendix 4. Regional comparisons from the last four seasons. source Brian Thomson . (Porosity)



Appendix 5. Cotton Irrigation Scheduling: Relationship between Yield and Canopy Temperature

Onoriode Coast, Rose Brodrick
CSIRO Agriculture, Narrabri

Irrigation scheduling options

Irrigation scheduling is an important aspect of irrigated farming, more so when irrigation water is scarce and costly. Australian cotton farms are constantly adapting their management practices to make the most use of limited water resources. Irrigation scheduling decisions in most cotton growing valleys have previously been guided by soil and weather based platforms. The use of neutron moisture meter and or capacitance probes for determining soil moisture status as a surrogate for measuring plant water status in Australian cotton farms is long established. More recently, weather based platforms, such as IrriSat, have also been tried. However, use of canopy temperature sensors (see Fig. 1), a plant based measure of water stress, is now beginning to gain traction.

Benefits of Scheduling Irrigation Using Canopy temperature sensors

- A direct measure of stress dependent on the crop (plant based)
- Non-destructive and remote measurement
- Continuous monitoring of plant water status
- Temperature sensors are relatively inexpensive
- Opportunities in the future to be spatial (covering larger areas)

Figure 1. Canopy temperature sensors. Top-down view of cotton canopy from a sensor

Study Aim and Methodology

During the last season (2014/2015) a pilot programme was conducted to independently monitor crop stress in cotton farms using canopy temperature sensors and to relate this with yield. Fifty canopy temperature sensors were deployed to 38 farms across eight valleys. The valleys were Macquarie, Gwydir, Balonne, Upper Namoi, Lower Namoi, Lachlan, Murrumbidgee, and Darling Downs. Farms selected were considered to be representative of a broad range of cotton farming systems in each valley. Irrigation systems in selected farms ranged from furrow, subsurface (or drip) to centre pivot irrigations.

Results

Table 1. Mean yield from participating valleys

Valleys	Mean yield (ba/ha)	Participating farms
Balonne	11.5	8
Darling Downs	11.6	2
Gwydir	11.9	9
Lachlan	15.0	1
Lower Namoi	10.7	2
Macquarie	14.7	8
Murrumbidgee	13.2	2
Upper Namoi	11.2	6

Yields of the valleys varied from 11 to 15 ba/ha (Table 1). This variation is quite representative of irrigated cotton growing areas. Canopy temperature data suggested that crops in high yielding farms (from the Macquarie valley) were generally less stressed i.e. spent less time on average above the optimum temperature required for crop development and yield. Whereas crops from lower yielding farms, which in this study were predominantly in the Namoi, were more stressed. Across all valleys there was a significant linear decrease in yield with increase in daily time canopy temperature exceeded optimum (Fig. 2). Increasing the average daily time a crop canopy exceeded the optimum temperature required for crop development, growth and yield seemed to incur a yield penalty.

We note that irrigation alone does not fully explain the variation in yield as presented in Figure 2. Other environmental factors that might contribute to the stress related variation in yield are valley differences in season length, soil types, rainfall amount and distribution, and length and frequency of extreme weather events. Accounting for these other variables might strengthen the relationship between canopy temperature and yield.

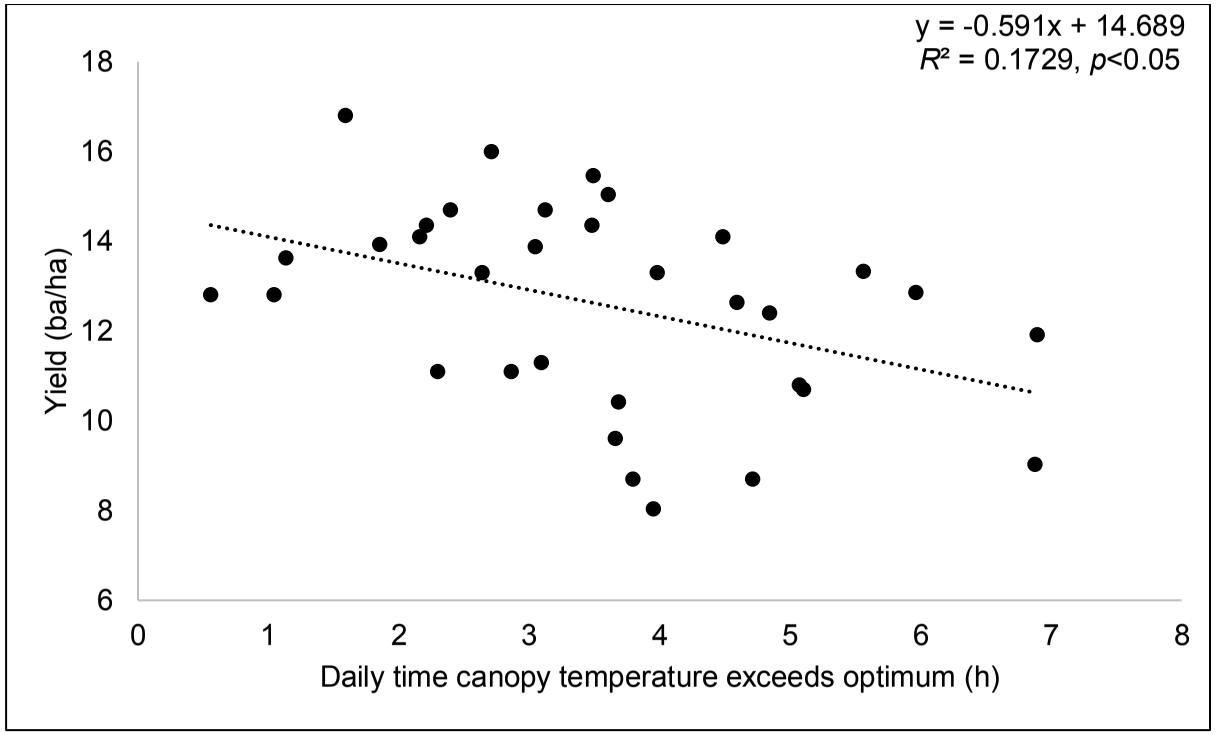


Figure 2. Yield versus daily average canopy temperature above optimum across all valleys

Conclusion

There has been significant interest from farmers in the use of canopy temperature sensors for fine tuning irrigation scheduling. In the absence of accounting for environmental differences in the valleys, a linear relationship between time above optimum canopy temperature and yield is a good indicator that canopy temperature could be an additional tool for farmers to use in optimising their irrigation strategies. More research effort is being put into testing the feasibility of using canopy temperature for irrigation scheduling and in future, extended to systems with less than optimal water allocation.

Acknowledgements

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