Information *when you need it*

2014/15

Macquarie Valley Cotton Field Trials

2014 /2015 TRIAL BOOKLET

INTRODUCTION

The aim behind the booklet is to collate some of the trials and case studies that happen over the season. There have been many delays in getting the information into the booklet for the 2014/2015 season for various reasons and we hope to be more timely next season. If you or your agronomist did some on farm trials or case studies in 2015/16, please send them through and we can put them in the next booklet (if you build it they will come). The printing and collation of this booklet has been funded by a 'grass roots' grant from CRDC.

The main project this booklet is looking at is a long term nutritional case study that has taken place on Tony and Broker McAlarys' farms "Millawa" and "Willowbend". The report looks at how the farm was able to build up Phosphorus levels on a long term scale. It also explains how phosphorus is available to plants through different pools. The report explores the roles of other trace elements and looks at how much is required by the plant and how much is removed.

This valley has a wealth of local knowledge gained by years of experience and its great collaborations like this that allow others to benefit from that knowledge. We would like to explicitly thank the McAlary family as well as Pat and the team at Sustainable Soils Management, and the consultant whose idea this was in the first place, Dave Klaare.

The CottonInfo nitrogen trial was conducted at Auscott Macquarie for the second year in a row. An enormous thank you goes to Jake Hall who was the agronomist who worked with me on this trial. The trial not only explored how different rates effect yield, it also looked at what nitrogen was in the soil before the trail, what was removed by the crop and what was left over post crop.

The second part of our CRDC funding was used to run a benchmarking/farm scale trial using canopy temperature sensors to monitor the crop in conjunction with soil probes below the ground. The trial is looking at the relationship of stress hours the crop is exposed to and yield.

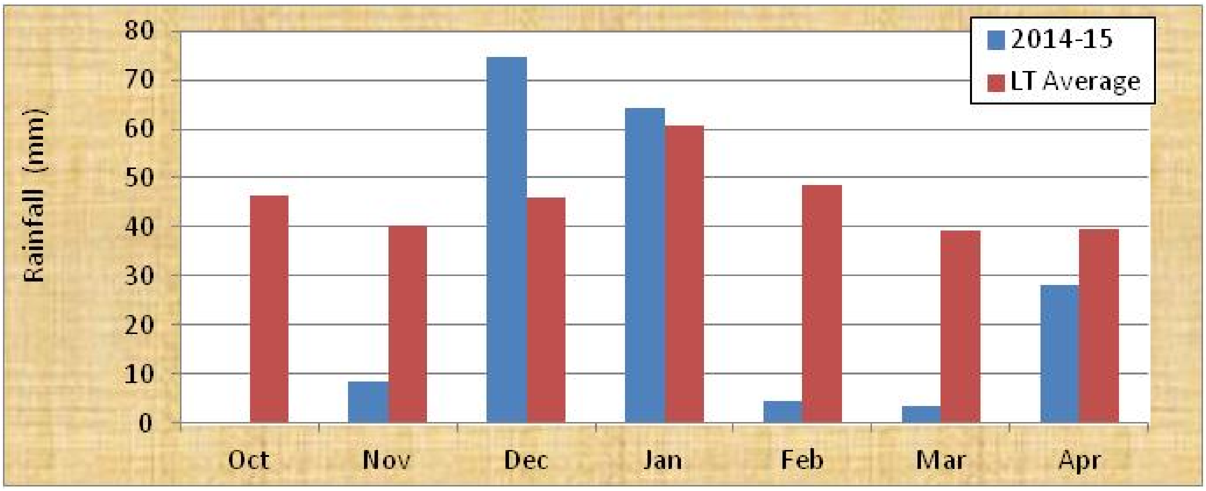
The Macquarie Cotton Growers Association is always striving to deliver value to its members by investing in worthwhile research projects and getting the results to the growers. We are lucky in the Macquarie Valley to have so many interested parties working to make growing cotton in the Macquarie Valley the best it can be.

Macquarie Valley

Crop Area

2014/15 saw around 9,800 ha of irrigated cotton planted and 600 ha of dry-land cotton. However, of the dry-land cotton planted, only around 150 ha was actually taken through to picking.

The hot dry winds early in the season brought much first irrigation forward. In corp rainfall has varied across the valley. Due to the fact much of this fell as isolated storms, it's hard to pin point exactly how much but in general Narromine has had around 260 mm, and Nevertire, Trangie and Warren were all averaging around 150 mm. The conditions were well above average in March however, we did experience a few mild patches in February that seem to have offset the extreme temperatures.



Growing conditions

Many growers have used a similar amount of water to last year, which is slightly above average. Some of the growers who have used the Canopy Temperature Sensors were able to see that while we had some extreme temps, the crop was for the most part able to keep its self cool. We had a few irrigation focused field days in February and looked at the new technology that is being adopted by growers.

Pest and Disease

Disease was a bit of an issue at the beginning of the season however, it was not widespread, with Black Root Rot, Rhizoctonia and Pythium making their presence known (in some cases at the same time), however this was mostly on crops planted early and growers were able to replant these areas in warmer conditions and the incidence was reduced. Some cases of Verticillium were present in the valley this season also.

Silver Leaf Whitefly numbers were varied over the valley and in some cases needed controlling, but on the whole it was a quiet year. The weeds were consistent this season, and you needed to stay on top of them early on when the cotton was smaller. On the insect front, it was pretty quiet. We have a few pests we haven't seen in numbers for some years (the Pale Cotton Stainer) rear their ugly heads.

Picture 1. Pale Cotton Stainer (photo by Jake Hall).

The above picture from Jake Hall from Auscott Macquarie was taken where some fields saw a rapid increase in damage, particularly in open cotton. Nymphs were developing in high numbers, usually inside a recently cracked boll. The spray decision around controlling this pest has to work in with the SLW population in mind. Good control was gained by using Pegasus™ where Whitefly was an issue.

Whitefly populations varied greatly across the region with some crops in the north of the Macquarie Valley needing control.

Good control was gained from early applications of IGR's that were able to control a current population and prevent the next generation from rearing their ugly heads.

Weed control was pretty effective when well timed, some escapes were present suggesting an increased tolerance to Glyphosate herbicide (Barnyard grass in particular).

Nutrition

On average across the valley, N was applied between 240 and 350 kg/ha to match the increasing yield targets. In most cases the grower put half up front and looked to water run urea for the remainder. This worked well as we did not have a lot of in crop rainfall to interfere. From some trial work done in the Macquarie Valley by Amanda Thomas of Cotton Info, this season did not leave much N behind. The crop seemed to use the Nitrogen available to reach the high yield targets.

The growth regulators played an important role this season; many growers have had good results from variable rate this season. From some reports, the later pixed crops did well as the season has produced the day degrees to make the most of the yield potential. However, at the northern end of the valley, in-crop control was the key to maintaining good even crops that were not given the opportunity to go rank.

From some flower tagging done in the valley, last effective flower seemed to be a week later around the 5th to 10th of February. Boll counts were very high and the top fruit accounted for a larger percentage of yields than the lower bolls. Boll counts were varied but are ranging on the good side with 150 -200 bolls/m pretty common. While boll counts were similar to the 2013/14 season, the boll weights were much higher.

Final Yield and Quality.

The 2014/15 year will be one to be remembered in the Macquarie Valley, although the total area planted was not going to set records. The yields produced from the 10,000 hectares planted were another story. There are a few key factors that probably contributed to the 12.9 bale average that the valley achieved. With smaller hectares, growers tended to plant their better fields in terms of water efficiency and soil types. A good percentage of the cotton grown was first year cotton, with not a lot of back to back country. Another key factor is that growers can pay a lot more attention to irrigation schedules when they have fewer fields in cotton. However, that being said yields were well above the previous year's average of 10.5 bales/ ha.

Variety performance has been exceptional this season with most growers averaging over 13 bales/ha with some growers averaging 15 bales/ha. Sicot 74BRF was the dominant variety in the Macquarie Valley with small areas of Sicot 71BRF. There was one Bollgard 3 trial in the Macquarie this season at Narromine. The result in this trial was very good with the CSX 802 BGF (Sicot 74 Family) yielding 15.54 bales/ha or 6.29 bales/ha. All quality was good in the trial. This season will see an expansive Bollgard 3 program with three Bollgard 3 variety trials as well a double skip Bollgard 3 trial. There will also be a number of Bollard 3 Ambassador sites which will be used to highlight the new Bollgard 3 varieties.

Quality was good for the most part; there were a few discounts in relation to colour from the April rain events. There was some 4 leaf cotton about for some of the later crops but in general most growers did manage to get their crops off in a timely manner.

Highlights of the Year.

The MCGA has had a change of leadership. The Committee voted in Ryan Pratten, who has replaced the ever dependable Brett Cumberland who held the Chair for the last three years. It is a great CGA with many younger growers starting to get on board and make some great decisions for our valley.

The Annual MCGA Awards dinner was held on Friday the 4th September at the Savannah Room at Western Plains Zoo. MC for the night was Adam Kay, a former Warren resident and District Agronomist who is now the CEO of Cotton Australia. Adam provided an insight into the progress of the cotton industry over the last 30 years.

Ryan Pratten from MPAC Narromine was recognised as the Tracserv Young Achiever of the Year Award. Ryan has recently taken over as the Chairman of Macquarie Cotton Growers Association, and was recently nominated as Young Achiever of the Year at the Australian Cotton Industry Awards.

The highly esteemed Jim Beale Memorial Services to the Industry Award was awarded by Skye Tyrwhitt. Skye was pleased to announce that the Committees of the four Macquarie Valley Irrigation Schemes who participated in the Private Irrigators Infrastructure Operators Programs; that being Marthaguy Irrigation Scheme, Tenandra Scheme, Trangie-Nevertire Irrigation Scheme and Narromine Irrigation Board of Management. Skye said she had personally seen the hard work, time and effort these hardworking committees had displayed for the positive impact of not only their individual schemes but the cotton industry as a whole.

The Suncorp Top Field Award was based on the highest ginned yield of any field over 40 ha. The four Macquarie Valley gins supplied the names of their ten highest yielding fields, and the growers were contacted to have the option to opt in or out of the competition. The winners were Alex and Mouse Ramsay of "Flintrock" Warren with an outstanding result of 16.8 bales/ha. Alex Ramsay and Andrew Cooper attributed the great results for the season to getting the basics right, starting with an impeccable plant stand, timing, good water and nutrition management.

Picture 2. Julie Wise (Cotton Australia), Peter Hollingsworth (Suncorp), Alex and Mouse Ramsay ("Flintrock") and Andrew Cooper (Landmark Warren).

The Chesterfield Farm of the Year Award was split into two categories; an above average farm and below average farm. The winner of the above average farm was again Alex and Mouse Ramsay of “Flintrock” Warren with a farm average of 15 bales/ha over 524 ha. The below farm average winner was “Quigley Farms” Nevertire, with 15.9 bales/ha over 47 ha, with Tony, Richard and George Quigley in attendance on the night. Tony attributed much of the success to Tom Quigley (much to his two brothers’ disgust) who could not make the night as he was overseas at the time on a Nuffield Scholarship.

Picture 3. David Searston (Chesterfield Australia), “Ritchie”, Tony and George Quigley (Quigley Farms).

Thanks to Mike Shields from Auscott, Luke Sampson from Monsanto, Bob Ford from CSD for their valuable contributions to the end of season report. As well as those who have contributed photos, Kerry Duncan and Jake Hall.

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MACQUARIE FIELD TRIALS, INDUSTRY RESEARCH AND ON-FARM TRENDS AND MANAGMEMENT OF PHOSPHORUS, POTASSIUM AND ZINC

Prepared for: **CottonInfo**

March, 2015

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Summary

Soil phosphorus moves little in the soil, but undergoes chemical transformation between available, readily available and slowly available forms (pools). Phosphorus in the available pool in the 0 to 30 cm layer of the average soil used to grow cotton in the Macquarie Valley can be depleted by as few as 2 high-yielding cotton crops. This phosphorus can be replenished from the readily available pool or from phosphorus fertilizer.

Fertiliser trials from 1992 to 2006 showed amongst variable results that there was a consistent yield benefit from applying fertiliser phosphorus in the Macquarie Valley.

Cottongrowers have adopted the practice of applying sufficient phosphorus to replace the nutrient exported by the following cotton crop. Research supports this practice, but there are some questions as to whether the phosphorus is being depleted in some parts of the soil while being present at adequate levels in other parts of the soil.

The yield response to potassium in Macquarie cotton crops has been more variable than for phosphorus. This is partly because the premature senescence caused by potassium deficiency appears to be triggered by a combination of factors that are not easy to predict. As a result, the majority of cottongrowers do not apply potassium fertilizer, and the average rate is sufficient to replace about half the potassium exported by cotton crops. This fertilizer potassium may be supplemented by potassium in the irrigation water.

Macquarie trials showed poor response to zinc fertilizer. Despite this, the industry appears to applying more zinc than is removed by cotton crops, perhaps in response to a decline in soil zinc where this nutrient is not replaced.

Introduction

Ten years ago cotton nutrient management decisions could be based on published results of recent local on-farm trials supplemented by industry recommendations. These on-farm trials are much less common today for a number of reasons, including drought, lack of a local cotton extension and research officer, change from a pioneering mentality to a more mature industry, and perhaps complacency with high cotton yields. (Figure 1). The result is that current nutrient management decisions are based on recent experiences industry recommendation, and recollection of the on-farm trial results for those who have been in the industry for a decade or more.

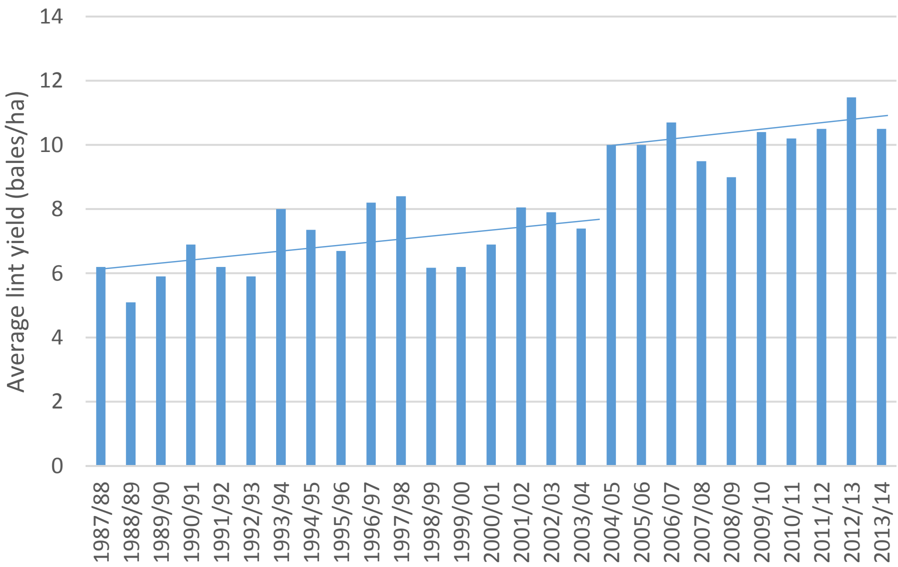

Figure 1. Average Macquarie cotton yields from 1987/88 to 2013/14. (From Macquarie trial reports in Table 3, then Australian Cotton grower yearbook to 2013/2014.)

The importance of nutrients to cotton nutrition can be estimated from the mass that is exported in relation to the mass that is available in the soil. Rochester and Constable (2005, Table 1) estimate that the mass of nutrients exported in a 12.5 bale/ha cotton crop ranges from 163 kg of nitrogen, down to 0.13 kg zinc/ha.

Table 1. Mass of selected nutrients (kg/ha) exported in cotton crops with a range of yields. (Calculated from Rochester and Constable, 2005).

Yield (bales/ha)	7.5	10	12.5	15
Nitrogen	61	116	163	200
Phosphorus	22	26	30	35
Potassium	38	47	46	55
Calcium	5	6	7	8
Sulphur	7	10	13	16
Zinc	0.09	0.11	0.13	0.16

The urgency in managing these nutrients can be estimated by calculating the time it will take to exhaust the nutrients that are available in the soil. This was calculated for Milawa by using the average concentration of nutrients from soil tests divided by the mass of nutrients exported in a

12.5 bale/ha cotton crop (Table 2). These values generally reflect the emphasis given to management of a range of nutrients. They also indicate why there is little emphasis in Australian cotton research on calcium, despite the large mass of calcium taken up by a cotton crop.

Table 2. Mass of nutrients available in Milawa soil as indicated by soil test in relation to the mass exported. (Note bulk density of 0 to 10 cm layer was assumed to be 1 g/cm³ while the remainder of soil was assumed to have bulk density of 1.5 g/cm³).

Nutrient	Depth range (cm)	Concentration in soil layer	Mass in Soil (kg/ha)	Uptake (kg/ha)	Export (kg/ha)	Years export in soil
Nitrogen	0 to 60	17 mg/kg	145	361	200	0.7
Phosphorus	0 to 30	18 mg/kg	60	52	35	2
Potassium	0 to 60	0.9 meq/100 g	2218	307	55	40
Calcium	0 to 60	22 meq/100 g	37400	350	8	4675
Sulphur	0 to 60	16 mg/kg	136	74	16	9
Zinc	0 to 30	0.53 mg/kg	2.12	0	0.16	14

The aim of this report is to summarize the results of Macquarie nutrition trials (Table 3), fundamental research into nutrition of Australian cotton and trends in nutrient levels on one local cotton farm (Milawa and Willowbend). The layout is to discuss these aspects of nutrient management for the nutrients of phosphorus, potassium and zinc that have been studied most closely in the Macquarie Trials.

Table 3. Macquarie Trial Reports used in this report.

Season	Compiler
1992-93	James Holden
1993-94	James Holden
1994-95	James Holden
1995-96	David Kelly
1996-97	David Kelly
1997-98	David Kelly
1998-99	Kirrily Rourke
1999-2000	Kirrily Rourke
2000-01	Kirrily Rourke
2001/02, 2002/03, 2003/04	Kirrily Rourke and Penny van Dongen
2005/06 Auscott Limited Trial Reports	Auscott Limited

Phosphorus

Industry Trends

The average rate of pre-plant phosphorus fertiliser has increased from 23 kg P/ha in 2001 to 31 kg P/ha for irrigated crops in 2013. (Roth Rural, 2013). This indicates phosphorus fertiliser has been applied at rate similar to phosphorus removal (Table 1) for more than a decade.

Macquarie Trial Results 1992 to 2006

The trend from 66 trials that contained valid comparisons indicates that a yield response could be expected in the year P is applied in the vast majority of sites where Colwell P is less than 10 mg/kg (Figure 2). The probability of yield increase and the magnitude of yield increase declined as Colwell P increased from 10 to 20 mg/kg, and the data indicates little yield response is expected when Colwell P is greater than 20 mg/kg.

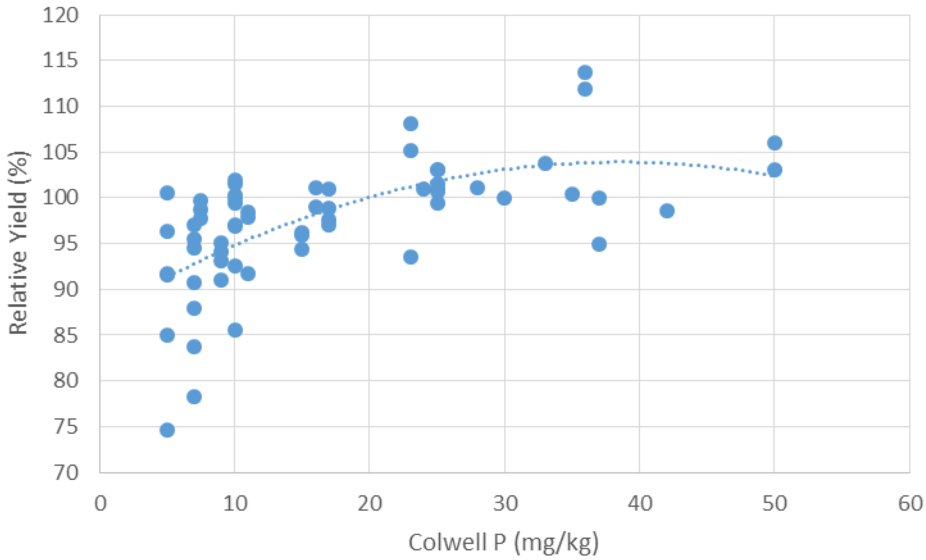

Figure 2. Cotton yield response to fertiliser phosphorus as a function of Colwell P (from Macquarie Trial Reports listed in Table 3).

More detailed analysis of trial results indicates that yield increase was independent of the amount of phosphorus applied, and was relatively consistent for control yield that ranged from 3 bales/ha to 12.5 bales/ha. The average yield increase from phosphorus fertiliser was consistently between 1.4% and 7% in 7 of the 8 years when experiments were conducted. Poorer response to P fertilizer occurred in a hot, dry year when there was insufficient water to fully irrigate the area that was planted (1997/98). Despite these consistent trends, the question of the critical soil phosphorus value for the current average yield in excess of 11 bales/ha could be addressed in future experiments.

The largest yield response to phosphorus occurred in farms that have predominantly backplain (myall) soil such as Auscott, Milawa Munthan and Tereweenah. A smaller phosphorus response was measured in many farms on the recent Macquarie floodplain such as Boomanulla, Wambandry and Weemabung.

Trends on Milawa

Milawa has a 20 year history of applying sufficient P to replace the P exported in the cotton crop (A. McAlary, pers comm.).

This was applied as MAP through a sidebuster until 2013 when the practice change to broadcast MAP and incorporation by discing and listing.

For the purpose of this analysis fields in the McAlary Partnership aggregation was divided into 5 groups;

- Marthaguy backplain on Milawa.
- Backplain with Light Clay on Milawa.
- Gilgaied backplain on Milawa.
- Recent Macquarie Backplain (grey soil) on Willowbend.
- Meander Plain (Red Soil) on Willowbend.

The analysis indicates that median Colwell P across both farms has increased by an average of 0.27 mg/kg/year. Colwell P is relatively consistent in the 4 groups of grey soil and has increased over 25 years from around 9 mg/kg in 1987 to around 15 mg/kg in 2015. Colwell P levels have been generally higher in the red soil on Willowbend than on the remainder of the aggregation, but there has been much more variation from year to year on the red soil than the grey soil.

These trends indicate that sufficient P fertiliser has been applied on Milawa to replace P exported by the cotton crops that have been grown.

Phosphorus in the Soil

The behaviour of phosphorus in the soil is complex when studied in detail as most processes are. For the purposes of farm scale nutrient management, the behaviour can be summarised:

- The finite mass of phosphorus in the soil is held in one of 3 pools (Figure 3).

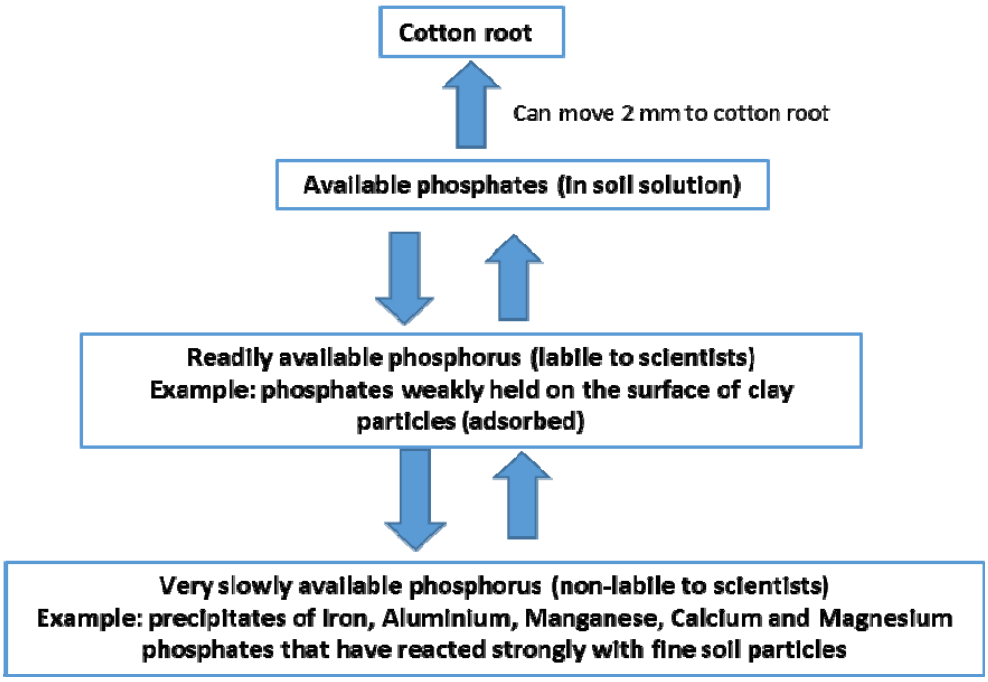

Figure 3. Simplified diagram of soil phosphorus pools (from Bailey, 2011).

- Cotton extracts phosphorus only from the available pool.
- The rapid movement of phosphorus from Available pool to the Readily Available pool means that P fertiliser generally stays where it is put in the soil. The exceptions are sand and soils with very high phosphorus levels (Bailey, 2011).
- In time, phosphorus removed from the Available pool is replaced by phosphorus from the Readily Available P Pool.
- The Colwell P test measures phosphorus that is in the Available pool and an approximation of phosphorus in the Readily Available pool that will become available in a season (Dorahy *et al.*, 2004). It is better correlated with cotton yield than the BSES P Test (McLaren *et al.*, 2013).
- The Phosphorus Buffer Index (Moody, 2007) is a more accurate measure of the interaction between Available pool and Readily Available pools. For this reason, it can be used to adjust critical Colwell P value for a given combination of soil and crop.
- Total phosphorus in the average of 17 sites assessed by Dorahy *et al.* (2004) was 300 mg/kg. The range sampled was sufficient to supply the phosphorus exported by between 7 and 60 cotton crops.

The cotton industry has sponsored detailed research into phosphorus nutrition in recognition of the importance of phosphorus nutrition in Australian cotton crops. Some of the research has focussed on the relatively poor skill of the Colwell P test as a predictor of situations where a response to fertiliser phosphorus could be expected.

Wang (2009) found that cotton extracted phosphorus from a range of profile depths rather than scavenging phosphorus solely from the surface layer. This pattern of phosphorus uptake has resulted in a decline in total phosphorus through the whole of the 0 to 45 cm soil profile at sites examined in northern NSW despite an increase in Colwell P at the sites assessed. This indicates that changes in Colwell P are not a reliable indicator of changes in Total P and that Available phosphorus should be measured in the subsoil as well as the topsoil to generate a reliable estimate of the phosphorus that is available to the crop.

Rochester (2010) found in a survey that sodic soil was more likely to have deficient levels of Colwell P than non-sodic soil. At one site he a measured a yield response to phosphorus fertilizer in a sodic soil (Colwell P of 6.4 mg/kg), but not a non-sodic soil (Colwell P of 13.3 mg/kg). At this site, phosphorus fertilizer was able to overcome some, but not all of the yield penalty from elevated soil sodicity

Phosphorus Management Summary

- The Australian cotton industry has adopted a practice of applying about the same amount of phosphorus as removed by following cotton crop.
- Phosphorus applied to soil generally remains where it is placed unless the soil is moved.

- Macquarie experiments found consistent yield responses to phosphorus fertilizer when Colwell P was less than about 10 mg/kg. This response became smaller till Colwell P reached about 20 mg/kg.
- The yield response was consistent across seasons and with a wide range of control plot yields.
- There is value in conducting limited phosphorus rate experiments in the Macquarie to check that these critical values are valid under the higher yields that are now grown.
- Colwell P has increased in the 0 to 30 cm layer at Milawa by 0.27 mg/kg/year. However, Wang (2009) cautions that this may not reflect an increase in total P.

Potassium

Industry Trends

The average pre-plant potassium fertiliser has increased from 8 kg/ha in 2001 to 26 kg/ha for irrigated crops in 2013 (Roth Rural, 2013). The 2013 rate is about half the potassium removed in a 12.5 bale/ha cotton crop (Table 2).

Macquarie Trial Results 1992 to 2006

Trends from the 35 trials in the Macquarie valley with valid comparisons were inconsistent. The key finding was that the range of soil potassium values measured in Macquarie cotton fields were a poor indicator of yield response to potassium fertiliser (Figure 4). The small yield decline in response to fertilizer potassium in soil with high potassium warrants further investigation.

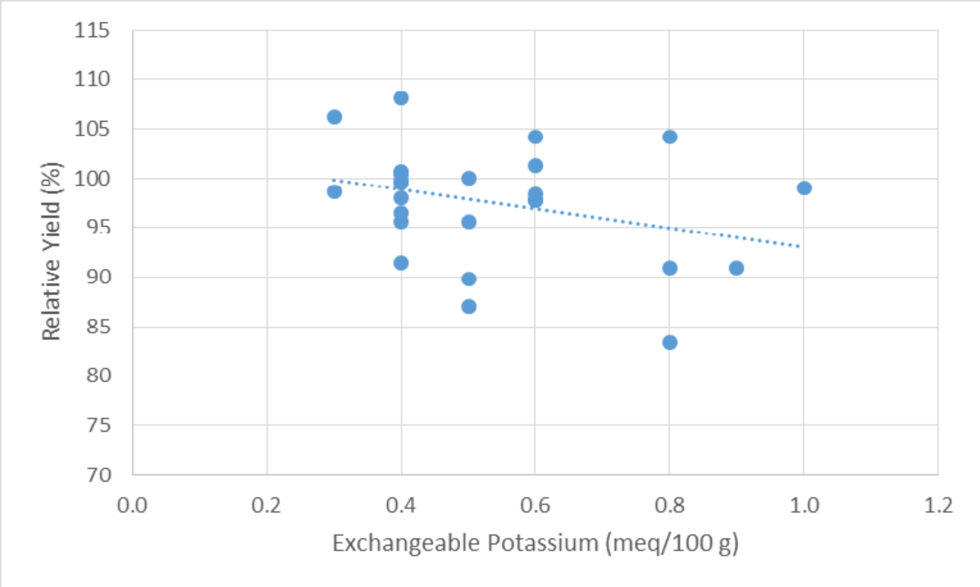

Figure 4. Cotton yield response as a function of soil potassium (from Macquarie Trial Reports listed in Table 3).

There were, however, some trends that were independent of soil potassium levels. These included that a consistent yield benefit from fertiliser potassium occurred only in 1 of the 4 years with more than 1 field trial. This was in 1997/98, which was the only year that no yield response to fertiliser phosphorus was found.
There was also a consistent pattern of larger yield response to potassium fertiliser in some, but not all farms on the recent Macquarie Floodplain including Boomanulla, Elengerah and Killowen. Consistent yield responses were also obtained in response to foliar potassium application on Buttabone.

Trends on Milawa

Soil potassium concentration has been lowest on the red soil on Willowbend at 0.6 meq/100g. This is above the concentration where a response to potassium is expected, and similar to the sites in the Macquarie where the potassium fertiliser experiments were conducted.

Average soil potassium levels have neither increased nor decreased between 1991 and 2015. This is despite no application of fertilizer potassium in this period and indicates that the soil and irrigation water have been able to supply the potassium that has been removed by the cotton crops.

There has been variation in the symptoms of potassium deficiency across the Milawa aggregation despite the small differences in measured soil potassium. Premature senescence was common only in 2 fields on the recent alluvium on Willowbend and only before 2004. These fields also yielded poorly at the time. Premature senescence has become much less common in these fields since the adoption of Bollgard/Roundup Ready cotton. The reduction in premature senescence is attributed to reduction in weed competition, less leaf damage from insecticides (A. McAlary, D. Klaare, pers comm.). The weed competition in these fields came from a dense infestation of bladder ketmia and chinese lantern, while the leaf damage came from the use of

organophosphate insecticides in Stage III of the Insecticide Resistance Management Plan.

Potassium in the Soil

Potassium in clay soil occurs most commonly in 2 forms associated with clay minerals. The first is adsorbed to the surface of clay crystals in the same way as calcium, magnesium and sodium are. This form is rapidly available to plants and is measured in soil tests. The second form is within the clay crystals, which is slowly available, and not measured in soil tests.

There has been a little cotton research into potassium nutrition of Australian cotton. Rochester (2010) found in a survey that potassium uptake by cotton declined as ESP increased. He found no response to potassium fertiliser in measurements of leaf nutrient concentrations, crop nutrient uptake or yield.

Wright (1996) attributed premature severance in cotton to potassium deficiency even though the soil had and adequate level greater than 0.5 meq K / 100 g. He claimed that premature senescence developed in these crops because the soil could not supply the potassium at the rate required by the crop despite there being adequate potassium in the soil.

These observations do little to clarify potassium management guidelines.

Potassium is also applied to irrigated cotton fields in irrigation water. The average potassium concentration of 46 samples of Macquarie River water from 1999 to 2002 was 2.9 mg/kg. This would supply 23 kg potassium/ha/crop in 8 ML/ha/crop, which is about half the potassium exported in a 12.5 bale/ha cotton crop.

Potassium Management Summary

- An industry survey indicates that about half Australian cottongrowers apply potassium fertiliser and the average of these growers apply about half the potassium that is exported by cotton crops.
- Water analyses indicate that as much as half the potassium exported by cotton crops could be replaced by irrigation water from the Macquarie River.
- The soil potassium concentration at sites that hosted Macquarie Valley potassium fertilizer trials was in the range where a moderate to low response to potassium fertilizer is expected. This is consistent with the small benefit to fertilizer potassium in these Macquarie trials.
- Given that premature senescence is observed in Macquarie cotton crops in soil with adequate potassium concentrations (M. Ceeney, pers comm.), there is uncertainty about optimum potassium management.
- These observations indicate that it is likely that optimum potassium management will rely on inputs other than soil potassium concentration. The factors that have some correlation with premature senescence include soil landscape (Macquarie trials), damage to leaves late in the season (Milawa observations), competition

from weeds (Milawa observations) and seasonal weather (Macquarie trials). Even though seasonal weather cannot be predicted, the positive yield response to foliar potassium indicates that growers may be able to modify management in response to climatic triggers to premature senescence. Predicting the onset of premature senescence may be a topic for future research.

Zinc

Industry Trends

Roth Rural (2013) reported that fertilizer zinc was applied on 60% of farms at an average rate of 3 kg/ha. This rate is estimated to be sufficient to supply about 20 years of zinc exported by a 12.5 bale/ha cotton crop (Table 3).

Macquarie Trial Results 1992 to 2006

Application of zinc fertiliser appeared to have little effect on cotton lint yield in the 14 trials in the Macquarie with valid comparisons (Figure 5). The exception was an average 1.3% yield increase in response to application of foliar zinc fertiliser on Buttabone.

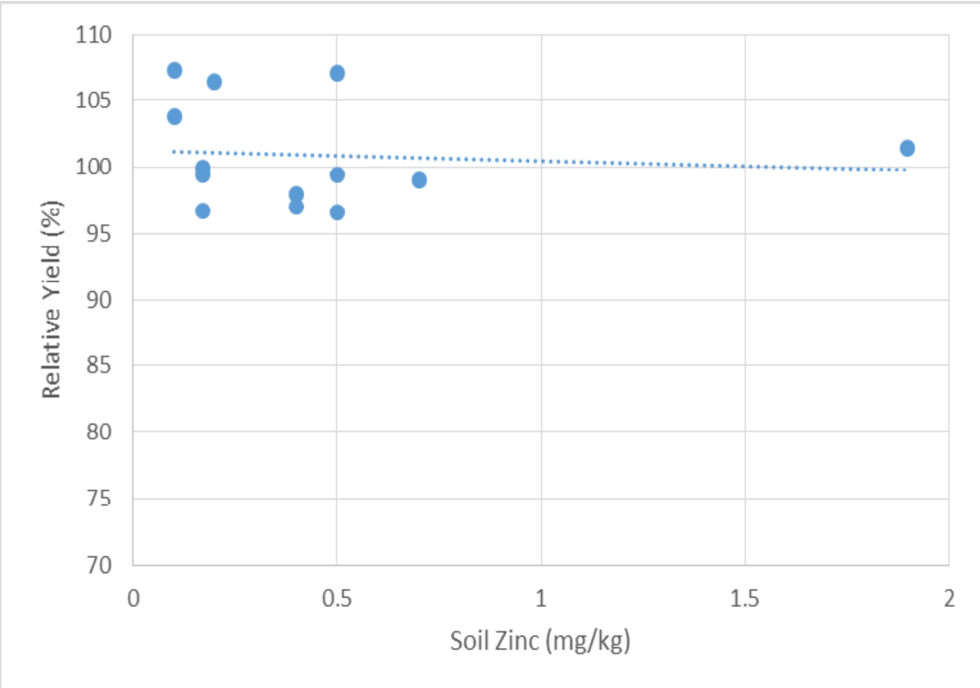

Figure 5. Cotton yield response to fertiliser zinc as a function of soil Zinc (From Macquarie Trial Reports listed in Table 3).

Trends on Milawa

Soil zinc concentrations on the Milawa aggregation average between 0.4 and 0.6 mg/kg, and have declined by an average of 0.005 mg/kg/year between 1991 and 2015. This is despite no fertilizer zinc being applied.

This lack of change in soil zinc concentration indicates that the soil has been able to supply most of the zinc that has been removed by the cotton crops.

Soil Zinc

Zinc is readily adsorbed by clay crystals, and moves relatively slowly at the dilute concentrations it is found in agricultural soil. It is more soluble in acidic than alkaline pH, and forms insoluble compounds with phosphorus.

The cotton industry has sponsored little research into zinc nutrition of cotton. One relevant finding is that Dowling and Lester (2001) measured higher soil zinc concentration after 4 applications of zinc fortified Monoammonium Phosphate (MAP) at yearly intervals than after 1 application of the same mass of zinc as zinc sulphate. This occurs despite the formation of insoluble zinc phosphate compounds soon after the zinc fortified MAP is applied.

Zinc Management Summary

- The Australian cotton industry appears to be applying substantially more zinc than is remove by cotton crops.
- The work of Dowling and Lester (2001) does not indicate a penalty to applying zinc and phosphorus fertiliser together, despite the short term immobilization of zinc by high phosphorus concentrations.
- The gradual decline in soil zinc on Milawa indicates that there may be benefit in applying zinc fortified MAP on a rotational basis to fields that grow cotton.

References

Bailey, G., 2011. Am I wasting phosphorus? McKillop Farm Management Group, Padthaway, SA. 10 pp.

Dorahy, C.G., Rochester, I.J. and Blair, G.J., 2004. Response of field-grown cotton (*Gossypium hirsutum* L.) to phosphorus fertilisation on alkaline soils in eastern Australia. Australian Journal of Soil Research, 2004, 42, 913-920.

Dowling, C.W., and Lester, D.W., 2001. Comparison of single high rate and multiple low rate fertiliser applications to increase available soil zinc supplies. Proceedings of 10th Australian Agronomy Conference. Downloaded from: http://www.regional.org.au/au/asa/2001/3/c/dowling1.htm#TopOfPage on 1/3/2015.

McLaren, T.I., Bell, M.J., Rochester, I.J., Guppy, C.N., Tighe, M.K., and Flavel, R.J., 2013. Growth and phosphorus uptake of faba beans and cotton are related to Colwell-P concentrations in the subsoils of Vertosols. Crop and Pasture Science. 64:825-833.

Moody, P.W., 2007. Interpretation of a single-point P buffering index for adjusting critical levels of the Colwell soil P test. Australian Journal of Soil Research. 45:55-62.

Rochester, I.J., 2010. Phosphorus and potassium nutrition of cotton: interaction with sodium. Crop and Pasture Science. 61:825-834.

Rochester, I., and Constable, G., 2005. Nutrients removed in harvested seed cotton. Downloaded from: www.cottoncrc.org.au/files/4eab6e0b-514a-4eeb-94e8.../CGNutRem.pdf on 20/3/15.

Roth Rural, 2013. Cotton growing Practices 2013. Downloaded from: www.crdc.com.au/sites/default/files/pdf/Cotton%20Growing%20Practices%202013.pdf on 1/3/2015.

Wang, X., 2009. Phosphorus acquisition characteristics of cotton (Gossypium hirsutum L.) compared with other crop species. Ph.D. Thesis, Latrobe University, Melbourne.

Wright, P.R., 1998. Premature senescence of cotton - the future of crop nutrition problems? Proceedings of 9th Australian Agronomy Conference. Downloaded from: http://regional.org.au/au/asa/1998/4/153wright.htm on 1/3/2015.

LIMITATIONS

The investigations described in this report identified actual conditions only at those locations where sampling occurred. This data has been interpreted and an opinion given regarding the overall physical and chemical conditions at the site.

Although the information in this report has been used to interpret conditions at the site, actual conditions may vary from those inferred, especially between sampling locations. Consequently, this report should be read with the understanding that it is a professional interpretation of conditions at the site based on a set of data. Although the data were considered representative of the site they cannot fully define the conditions across the site.

Regional Development Officer Nitrogen Management Trials 2014/15 Season.

Title: Nitrogen Fertiliser Use Efficiency in the Macquarie Valley

Author: Amanda Thomas

Key findings

Trial Aim

The trials aimed to go beyond the typical rate trial and take into account

- what N was in the soil before the crop
- what was removed by the crop and seed N sampling
- what N was left in the treatments after crop removal
- look at relationship between Seed N % and Nitrogen Fertiliser Use Efficiency. Examine the effect on yield of the different rates of Nitrogen and track the Nitrogen within the cropping cycle.

Replicated Nitrogen Fertiliser Use Efficiency trials were rolled out across most of the cotton growing regions last season by the Regional Development Officers with an aim looking further into where our Nitrogen ends up and how efficiently it was used.

Trial Details

Location: Auscott Macquarie Agronomist: Jake Hall

Soil type: Grey Clay

Rainfall: Oct-Mar (mm) 160 mm

Planted: 7th October

Picked: 28th April

Treatments: Treatments were applied to plots that were 8 rows wide on 1.5 m beds. Each treatment was replicated 4 times across the field.

Up front N kg/ha	Water run N kg/ha	Total N
0	160	160
60	160	220
100	160	260
140	160	300
180	160	340
220	160	380

Figure 1. Nitrogen Rates and Delivery Method.

The planting configuration is 60 inch (or 1.5 m beds). This should be noted when looking at the final yields. The crop received the remainder of N via water run Urea.

Management Notes

Planted: 7^{th} October

Variety: Sicot 74BRF

Previous crop: Cotton / fallow / wheat

Other Nutrients: P, K, and Zn - 20 kg of N was applied as MAP

Seasonal Review

There was a gappy plant stand in some places but extensive plant counts showed these were consistent across all treatments (7 – 8 plants/m). Once established, the crop grew well and tended to fill in most of the gaps. The season had 35 cold shock days and 40 hot days above 35° C. There was 2,430 DD (long term average 2,140 DD).

Figure 2. Plant stand did have some gaps but was consistent across all treatments.

Trial Results and Discussion

Each individual plot was picked separately and yield calculated taking into account modules produced on the area picked. The treatments were ginned separately to be able to gain separate "turn out" and quality data. Quality was consistent across all treatments.

N Available to the Plant

The soil tests measured Nitrate-N pre and post crop. The soil Nitrate-N concentration reported by the soil analysis was converted to kg N/ha by multiplying the nitrate in the soil x bulk density x test depth/10. The graph below shows all applied fertiliser N and soil Nitrogen (pre-sowing and post-harvest) in the 6 treatments.

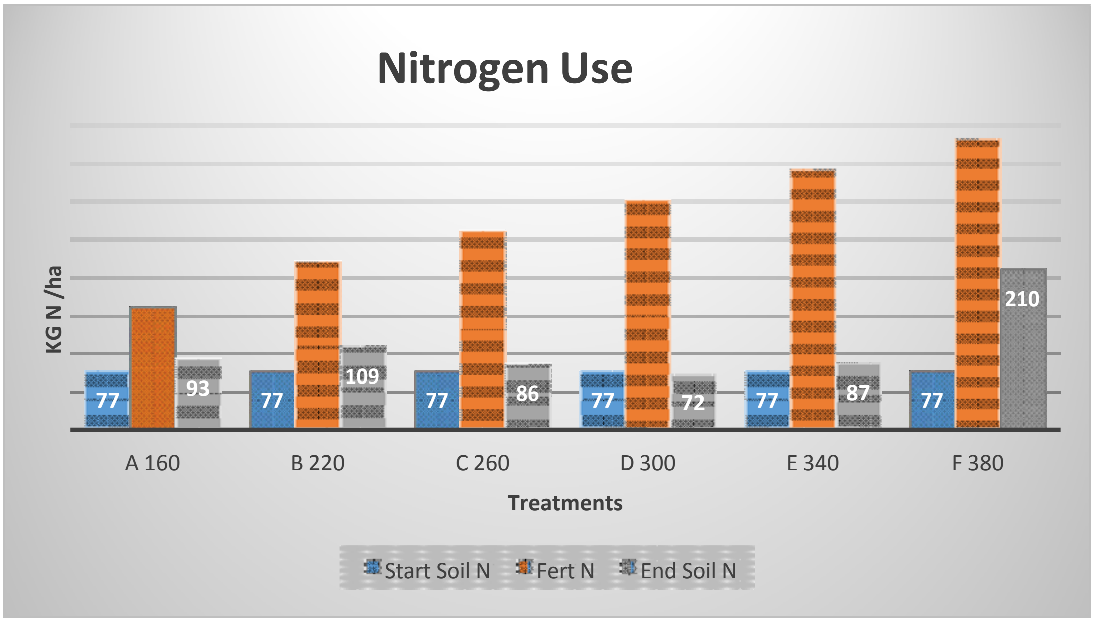

Figure 3. Nitrogen in the soil applied, pre and post crop.

The above graph shows that there was no linear relationship between the amount of Nitrogen applied and what was was left in the soil. This is not unsusual, as much of the unused fertilser N can be lost from the soil through denitrifcation (gaseous loss), leaching of nitrate (either down the soil profile or off the field in run-off irrigation water).

Yield

The analysis of the yield results below showed that there was no statistically signifcant differnce in yield between the six treatments. Given that the field had 77 kg of Nitrogen when sampled to a depth of 90 cm and 160 kg was applied as water run urea in the growing season, it is evident that the crop was able to mineralise enough Nitrogen to meet demands and still have some left in the soil post crop (63 kg).

Analysis of Variance – Lint yield

Variate: Actual YLD					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
N applied	5	2.8325	0.5665	1.30	0.289
Residual	30	13.0522	0.4351		
Total	35	15.8847			

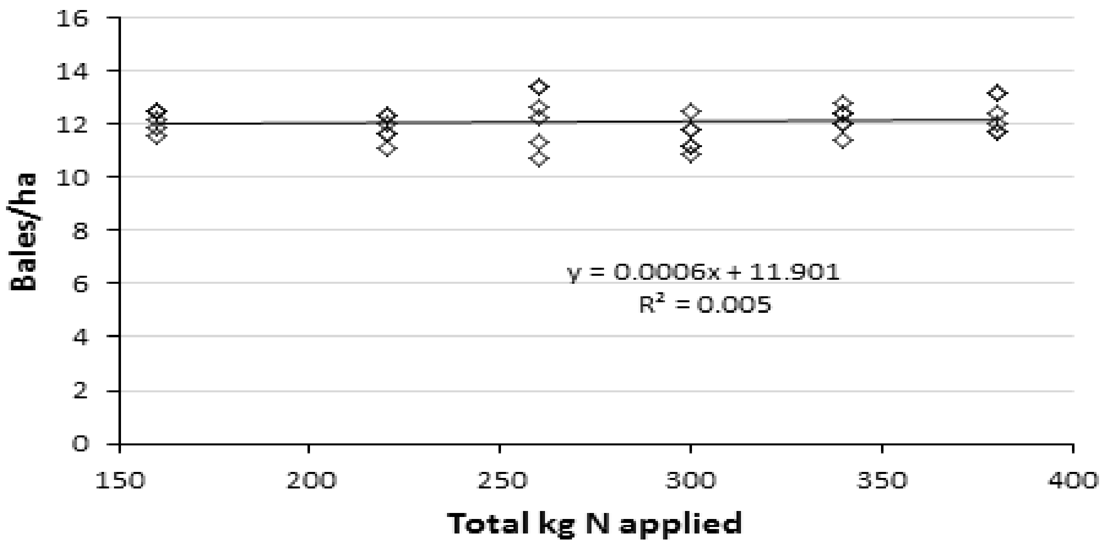

Figure 4. Yield in bales/ha for each of the treatments.

There was essentially no increase in lint yield from adding N fertiliser in excess of 160 kg N/ha. We can gain some idea of what the economic optimum N fertiliser rate may have been by examining the relationships between yield, N fertiliser applied and seed N%.

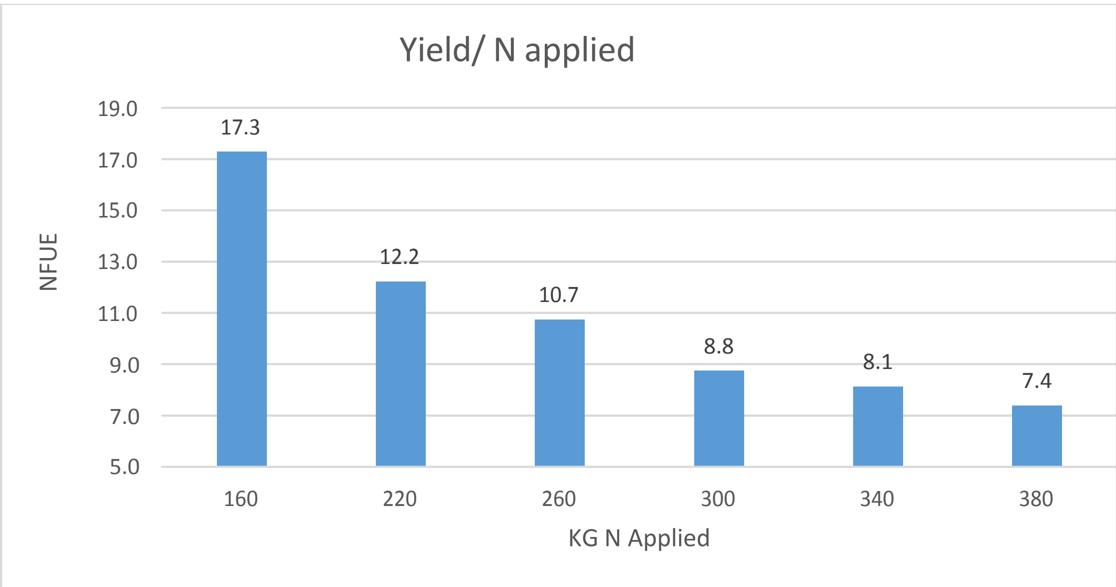

Figure 5. Applied Nitrogen Fertiliser Use Efficiency (optimum is 15.5) Rochester 2014.

When the lint yield is divided by the N fertiliser applied, an index is formed which can be related to the optimum N fertiliser rate. Long term studies have shown that the optimum normally lies around 15.5 (range 13-18). Figure 5 below shows that treatments that recieved more than 160 kg N/ha showed poor N fertiliser use-efficiency and that 160 kg N/ha was probably close to the economic optimum N fertilier rate for this site. Adding more N fertiliser did not increase yield but reduced profit.

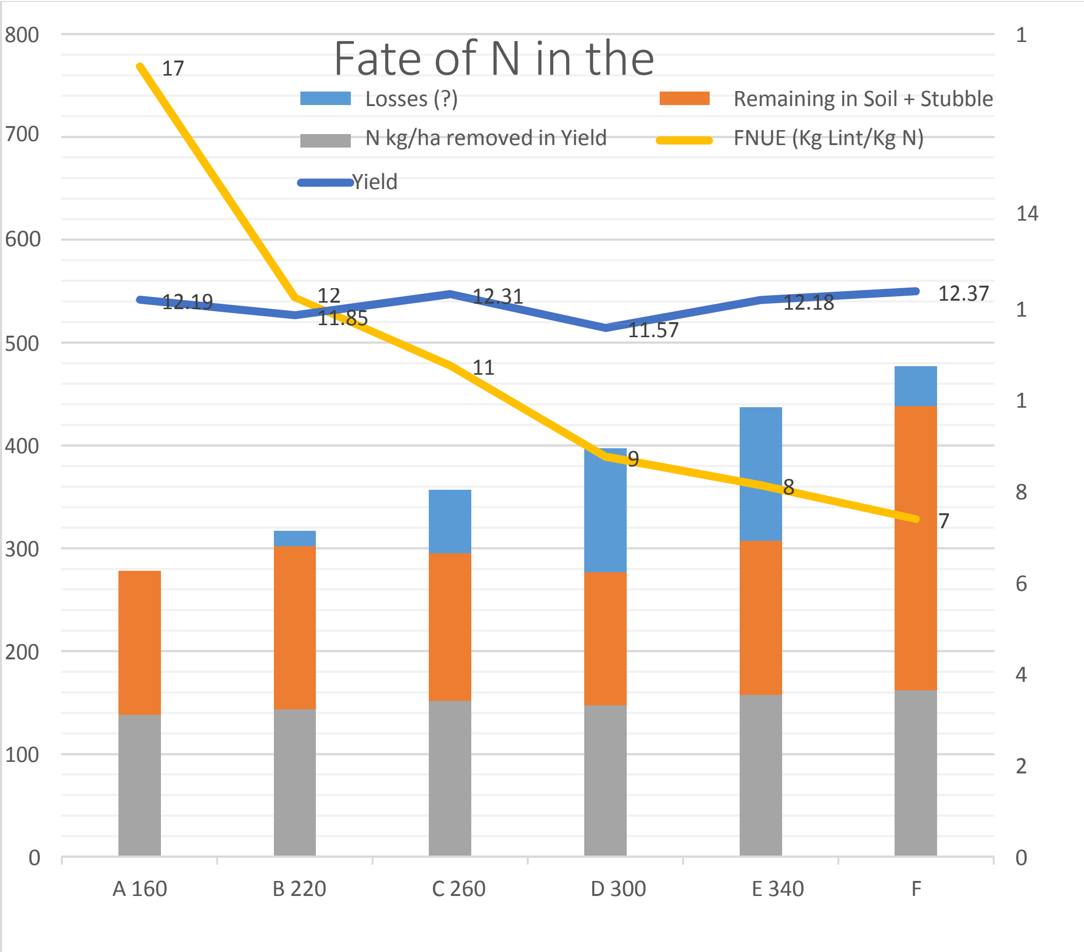

Figure 6. Nitrogen balance, Nitrogen fertiliser use, efficiency and yield. (Source Jake Hall Auscott).

By measuring N before and after the crop across the treatments we were able to state that Nitrogen was not a limiting factor in this trial. There was no yield difference across the treatments and the highest rate had the highest Nitrogen still remaining in the soil. Figure 7 shows the location of the Nitrogen over the three depths tested. The location of N in the profile can impact its availability and losses. Additional information on the rate of mineralisation and any major loss events in the season would be required to better understand the whole Nitrogen cycle. Next season, a new soil test will be trailed that measures in crop mineralisation of Nitrogen. The pre-season soil samples were taken across random sections of the whole field and the post soil tests were taken within each treatment across two of the replications.

The Nitrogen Fertiliser Use Efficiency (NFUE) was calculated only on the applied Nitrogen and does not take into account what was already in the soil. The formula is yield in kg/ha divided by the applied N fertiliser in kg/ha. Rochester, 2013 determined the optimum NFUE to be in the range of 13-18 kg/lint per kg/N applied. Figure 6 shows only two of the rates were within the optimum range for NFUE, the yield was not significantly affected by the more efficient rates.

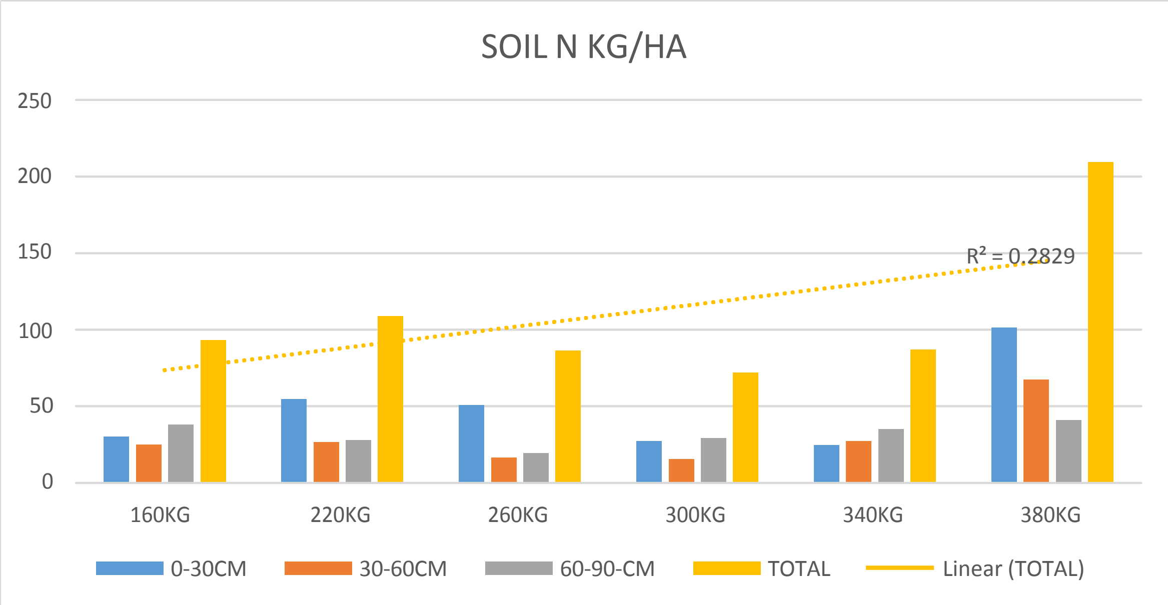

Figure 7. Soil Nitrogen post cotton crop.

CONCLUSION

Many relationships that can occur within the cotton crop were examined by the CottonInfo Nitrogen Trial. This is the second year we have conducted the trials. The main take home message is that Nitrogen was not the limiting factor for the 2014/2015 season. The results showed the same yield for $200/ha less Nitrogen fertiliser applied. This yield is dependent on the contribution of the pre-plant soil Nitrogen and the in-crop mineralisation of Nitrogen. The RDO trials from other regions have demonstrated that both of these sources can be quite variable, emphasizing the need to do pre-plant soil tests and to take the previous cropping history and soil health into consideration when developing a nutrient budget.

The trials continue to demonstrate that Nitrogen availability is impacted by a range of factors, making a generic Nitrogen application unrealistic. We understand that growers want to ensure that Nitrogen does not limit production, but the trials would indicate that there is the opportunity in many cases to reduce Nitrogen fertiliser applications while still maintaining the potential for high yields.

Next season, the RDO's will be looking more specifically at the impact of Nitrogen leaching from early season irrigations, the potential to test for in-crop mineralisation and the opportunity to refine in-crop Nitrogen applications based on petiole testing.

REFERENCES

Rochester, IJ., 2012. Using Seed Nitrogen Concentration to Estimate Crop N Use Efficiency in High-Yielding Irrigated Cotton. Field Crops Research. 127, 140-145 pp.

Rochester, IJ., 2014. Growing High Yielding Nitrogen Efficient Cotton – 2014 Australian Cotton Conference paper. 1 – 3 pp.

Canopy Temperature Sensors

In 2014-2015, the Macquarie Cotton Growers Association opted to use the CRDC Grass Roots Grants to ground truth how monitoring the temperature of the canopy can help growers make better decisions around irrigation.

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 CSIRO has developed a new science approach using infra-red temperature sensors that can measure the leaf surface temperature, and along with the knowledge of cotton's optimum plant temperature of 28°C, forms the basis for quantifying plant stress. Many biochemical responses go on in the plant (eg. photosynthesis, respiration) and each of them have optimum temperatures.

By measuring the accumulated hours above an optimum temperature of 28°C, we are able to calculate the time that the plant is spending under stress conditions. Using continuous canopy temperature sensors may enable managers to minimise stress. A number of trials have been conducted using the infrared temperature sensors trying to work out how to schedule irrigations based on the number of hours above the optimum temp. Once this threshold is reached then the crop is watered.

In order to get some number around how accumulation of stress hours in the Macquarie Valley works, we leased some Canopy Temperature Sensors from CSIRO and placed them across as many different irrigation systems, soil types and locations as possible. The decision on where to place the sensors was decided by looking at who had different farming systems and decent mobile signal.

The data from the season was then analysed by the CSIRO and they were able evaluate the hours spent above the optimum temperature in this particular season. The highest yielding fields also had the least amount of stress hours.

Plant stress monitoring using canopy temperatures

Alex Ballhausen Farm, Macquarie Valley

Background

Irrigation scheduling is a major component of cotton farm management that can have implications on final yield and quality. Australian cotton farmers use their experience and/or the soil water status to make a decision regarding the timing of irrigation application. More recently, canopy temperature (Tc) which is a non-destructive plant-based measure of water stress, has been proposed as a tool in irrigation management. In this method, the decision to irrigate a cotton farm is based on the length of period the Tc exceeds the optimum temperature for physiological functioning of cotton plants, i.e. 28 °C while accounting for other environmental factors that may influence Tc. Stress hours were reset to zero after an irrigation or rainfall of ≥ 25mm was received within 24 hours.

Canopy temperature was monitored on different cotton farms in the Macquarie Valley during 2014-15 season by installing one or more Tc sensors per farm. These farms were irrigated using farmer experience and/or monitoring of soil moisture status. Canopy temperature data was used to assess the plant stress levels on selected farms.

Results and Discussion

Yield varied between 12.6 bales ha^{-1} and 16.8 bales ha^{-1}, although the highest yielding farm could not be included in the analyses (Figure. 1) as Tc sensor malfunctioned most of the cotton season. There was a strong relationship between yield and the average time the canopy temperature exceeded the optimum temperature (28 °C) as shown in Figure 1.

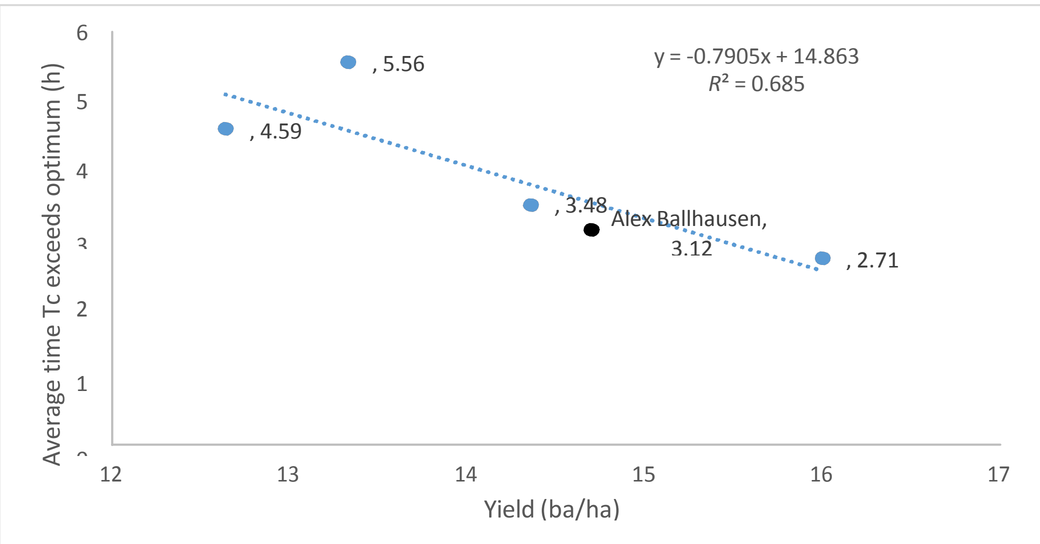

Figure 1: The relationship between yield and the average time canopy temperature (Tc) exceeded the optimum temperature.

The Alex Ballhausen farm was irrigated on most of the days using a Centre Pivot irrigation system. The average time the canopy temperature exceeded the optimum canopy temperature was 3.12 hours which is one of the lowest among farms studied in the Macquarie Valley. The cotton yield of 14.7 bales ha^{-1} at this farm was one of the highest among participating farmers in the Macquarie Valley.

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Plant stress monitoring using canopy temperatures

Auscott Farm, Macquarie Valley

Background

Irrigation scheduling is a major component of cotton farm management that can have implications on final yield and quality. Australian cotton farmers use their experience and/or the soil water status to make a decision regarding the timing of irrigation application. More recently, canopy temperature (Tc) which is a non-destructive plant-based measure of water stress has been proposed as a tool in irrigation management. In this method, the decision to irrigate a cotton farm is based on the length of period the Tc exceeds the optimum temperature for physiological functioning of cotton plants, i.e. 28 °C while accounting for other environmental factors that may influence Tc. Cumulative stress hours are reset to zero after an irrigation or rainfall of ≥ 25mm was received within 24 hours.

Canopy temperature was monitored on different cotton farms in the Macquarie Valley during 2014-15 cotton season by installing one or more Tc sensors per farm. These farms were irrigated using farmer experience and/or monitoring of soil moisture status. Using the Tc method described above, stress levels were assessed between the irrigations.

Results and Discussion

Yield varied between 12.6 bales ha^{-1} and 16.8 bales ha^{-1} among the participating farmers, although the highest yielding farm could not be included in the analyses (Figure. 1) as Tc sensor on this farm malfunctioned most of the cotton season. There was a strong relationship between yield and the average time the Tc exceeded the optimum temperature (28 C) as shown in Figure 1.

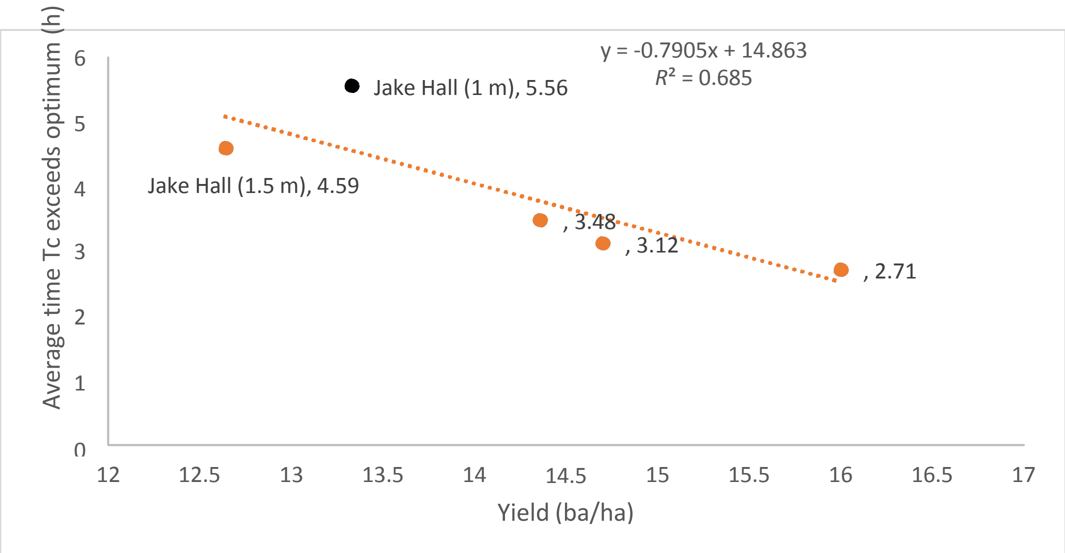

Figure 1: The relationship between yield and the average time Tc exceeded the optimum temperature.

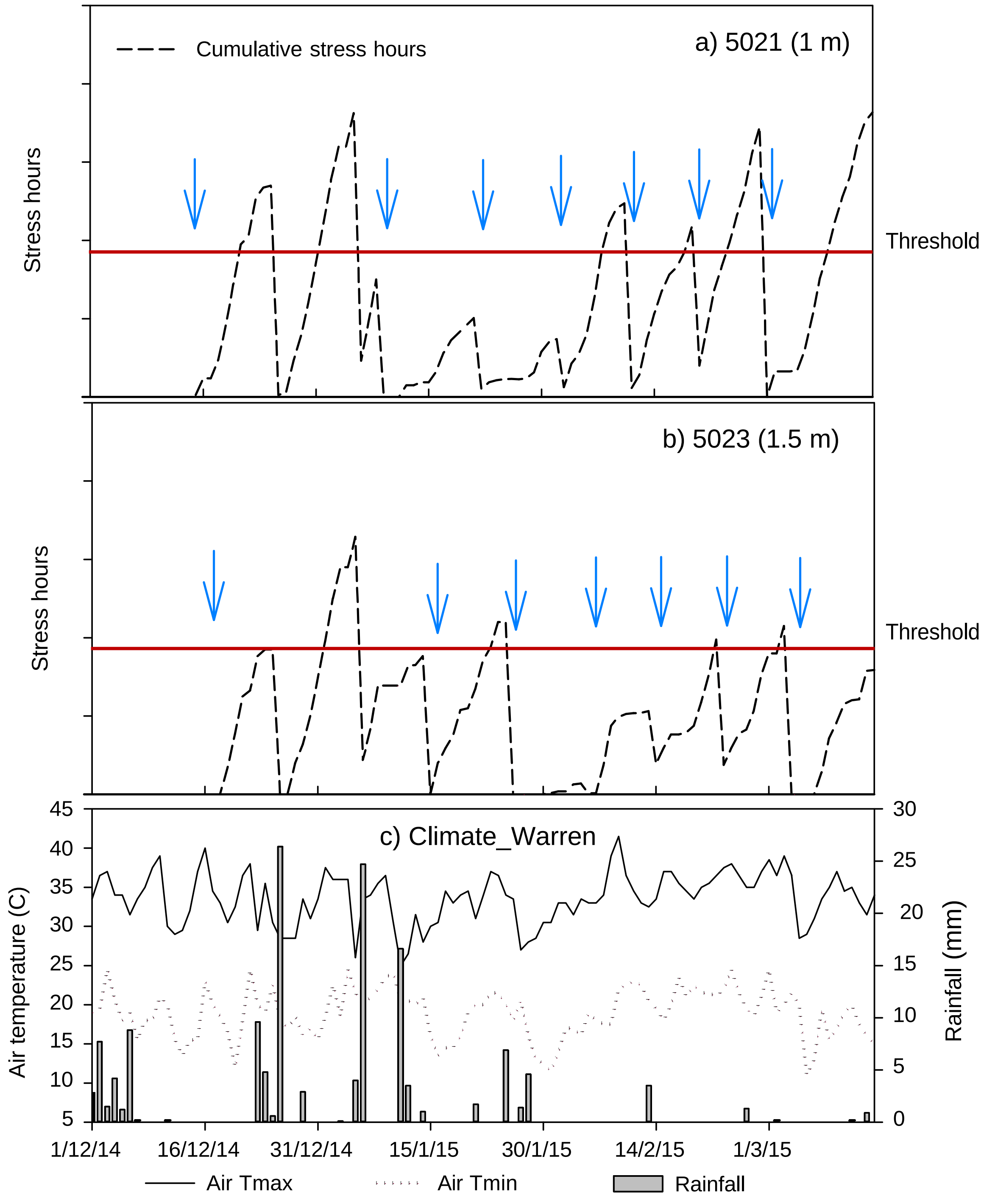

Figure 2: a) Cumulative stress hours above optimum temperature showing the plant stress levels between irrigations; blue arrows show the time of irrigation and red line shows the threshold for stress hours; b) Climate data measured by a weather station at Warren.

At the Auscott Farm, the canopy temperature was monitored in two separate fields. One field was planted on 1 m wide beds while the other on 1.5 m beds. The average time the canopy temperature exceeded the optimum temperature was higher in the 1 m field suggesting plants in the 1 m field were generally more stressed than those in the 1.5 m field.

The cumulative stress data in Figure. 2 shows that there may be an opportunity to optimize the irrigation scheduling by monitoring the plant stress levels in real time. For example, in the 1 m field, there might have been an opportunity to delay the irrigations applied on the 15th January, 26th January and 5th February as plants were well below the stress threshold (Figure. 2). Such earlier irrigations may also have increased the chances of water logging which can affect the physiological functioning of plants, as well as result in large gaseous losses of N through the process of denitrification which occurs in low oxygen soil conditions. Conversely, the last three irrigations in the 1 m field were possibly delayed for too long which might have resulted in stress accumulation. Previous research has shown that water stress during peak flowering and early boll development can result in significant yield reductions in cotton. Plants also appeared stressed in March; however, this may not have affected yield if plants were mature (i.e. ~20% bolls open) at that stage.

It appears that irrigation applications in the 1.5 m field managed to avoid plant stress better than the 1 m field although there might have been an opportunity to delay the irrigations applied on the 5th and 14th February as plant stress level was well below the threshold (Figure. 2). Relatively more timely irrigations in the 1.5 m field resulted in lower average stress levels than the 1 m field (Figure. 1). Rainfall was also utilized more efficiently in the 1.5m field. Better yield in the 1 m field despite higher stress levels is most likely related to higher plant density, i.e. 8.5 plants m^{-2} in the 1 m field versus 8 plants m^{-2} in the 1.5 m field.

It could be argued that keeping the interval between irrigations constant may not be realistic as water requirements for plants increase with development when water requirements are high. As such, decreasing the time interval between irrigations progressively with the season may improve water use efficiency. Canopy temperature method enables measuring plant stress in real time quantitatively which may be a useful tool in irrigation scheduling.

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Plant stress monitoring using canopy temperatures

Stu Denston Farm, Macquarie Valley

Background

Irrigation scheduling is a major component of cotton farm management that can have implications on final yield and quality. Australian cotton farmers use their experience and/or the soil water status to make a decision regarding the timing of irrigation application. More recently, canopy temperature (Tc) which is a non-destructive plant-based measure of water stress, has been proposed as a tool in irrigation management. In this method, the decision to irrigate a cotton farm is based on the length of period the Tc exceeds the optimum temperature for physiological functioning of cotton plants, i.e. 28 °C while accounting for other environmental factors that may influence Tc. Stress hours were reset to zero after an irrigation or rainfall of ≥ 25mm was received within 24 hours.

Canopy temperature was monitored on different cotton farms in the Macquarie Valley during 2014-15 season by installing one or more Tc sensors per farm. These farms were irrigated using farmer experience and/or monitoring of soil moisture status. Using the Tc method described above, stress levels were assessed between the irrigations.

Results and Discussion

Yield varied between 12.6 bales ha^{-1} and 16.8 bales ha^{-1} among the participating farmers, although the highest yielding farm could not be included in the analyses (Figure. 1) as the Tc sensor on this farm malfunctioned most of the cotton season. There was a strong relationship between yield and the average time the Tc exceeded the optimum temperature (28 °C) as shown in Figure 1.

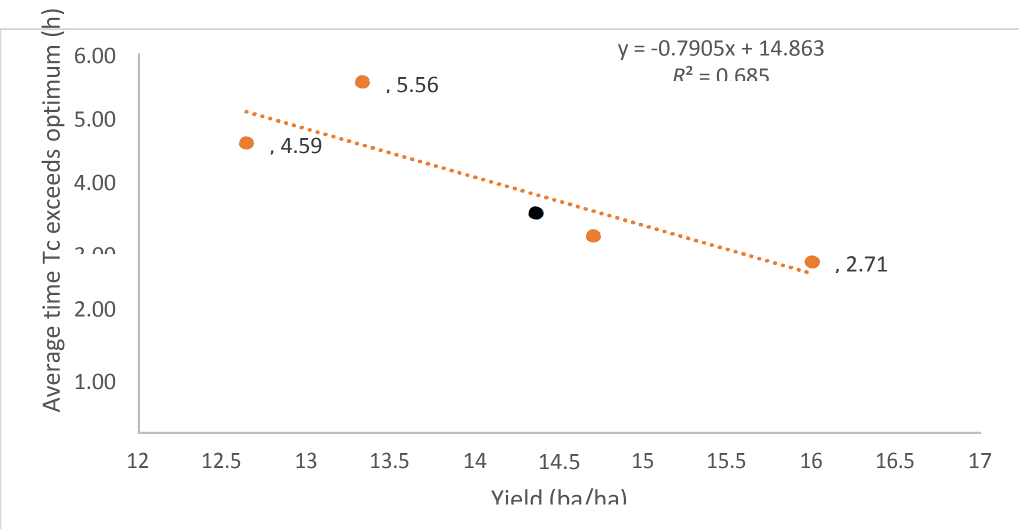

Figure 1: The relationship between yield and the average time the canopy temperature (Tc) exceeded the optimum temperature; the black dot represents the Stu Denston Farm.

At Stu Denston's Farm, the Tc data could only be collected for the period starting 5th February, 2016. Four irrigations were applied in this period. Total rainfall received in this period was ~18 mm; however, weather data was not available after the 2nd March, 2016 (Figure. 1A).

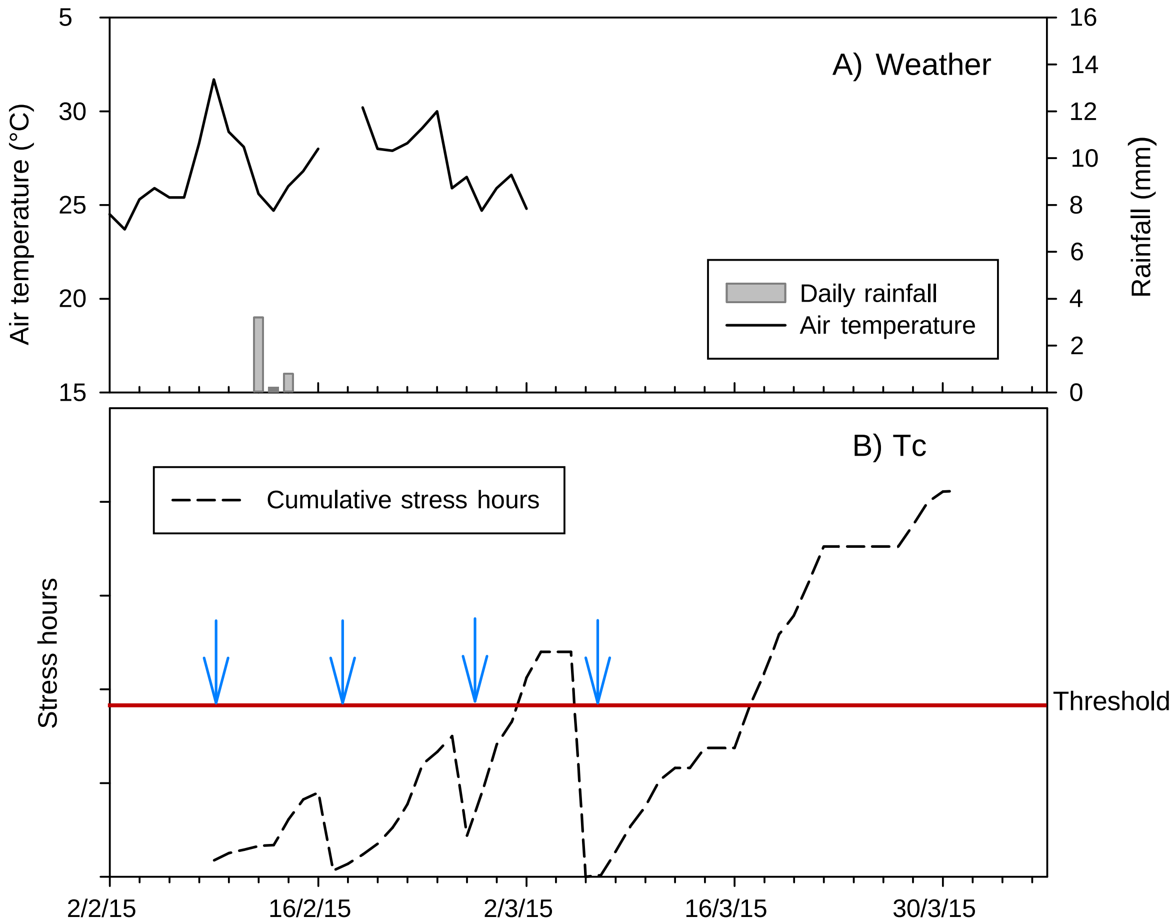

Figure 2: a) Average daily temperature and rainfall measured at Nevertire weather station and, b) Cumulative stress hours above optimum temperature showing the plant stress levels between irrigations; blue arrows show the time of irrigation and red line shows the threshold for stress hours.

The cumulative stress data (Figure. 2) shows that there may be an opportunity to optimize the irrigation scheduling by monitoring the plant stress levels. For example, plants were well below the stress threshold (red line) at the time of irrigations applied on the 17th and 26th February (Figure. 2), which may offer the opportunity to delay these irrigations for a few days (Figure. 2). Such earlier irrigations may also have increased the chances of water logging which can affect the physiological functioning of plants, as well as result in large gaseous losses of N through the process of denitrification which occurs in low oxygen soil conditions. Conversely, the irrigation applied on 6th March might have been delayed for too long as plants reached the stress threshold around 1st March (Figure. 2). An earlier irrigation might have avoided the stress recorded between 1st and 6th March. Previous research has shown that water stress during peak flowering and early boll development can result in significant yield reductions in cotton.

Plants also appeared stressed after 16th March; however, this may not have affected yield if plants were mature (i.e. ~20% bolls open) at that stage.

It could be argued that keeping the interval between irrigations constant may not be realistic as water requirements for plants increase with development. As such, decreasing the time interval between irrigations progressively with the season may improve water use efficiency. Canopy temperature method enables measuring plant stress in real time quantitatively which may be a useful tool in irrigation scheduling.

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Plant stress monitoring using canopy temperatures

J. & S. Crawford Farm, Macquarie Valley

Background

Irrigation scheduling is a major component of cotton farm management that can have implications on final yield and quality. Australian cotton farmers use their experience and/or the soil water status to make a decision regarding the timing of irrigation application. More recently, canopy temperature (Tc) which is a non-destructive plant-based measure of water stress, has been proposed as a tool in irrigation management. In this method, the decision to irrigate a cotton farm is based on the length of period the Tc exceeds the optimum temperature for physiological functioning of cotton plants (i.e. 28 °C while accounting for other environmental factors that may influence Tc). Stress hours are reset to zero after an irrigation or rainfall of ≥ 25mm is received within 24 hours.

Canopy temperature was monitored on different cotton farms in the Macquarie Valley during 2014 -15 season by installing one or more Tc sensors per farm. These farms were irrigated using farmer experience and/or monitoring of soil moisture status. Canopy temperature data was used to assess the plant stress levels and its relationship with yield.

Results and Discussion

Yield varied between 12.6 bales/ha^{-1} and 16.8 bales/ha^{-1}, although the highest yielding farm could not be included in the analyses (Figure 1) as the Tc sensor malfunctioned most of the cotton season. There was a strong relationship between yield and the average time the canopy temperature exceeded the optimum temperature (28 °C) as shown in Figure 1.

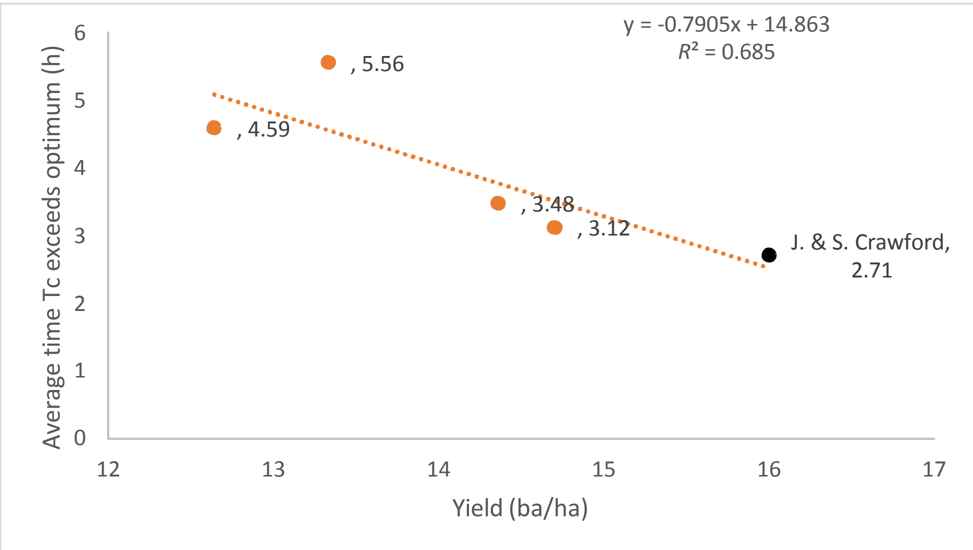

Figure 1. The relationship between yield and the average time the canopy temperature (Tc) exceeded the optimum

The J. & S. Crawford Farm was irrigated on most of the days using subsurface drip irrigation. The average time the canopy temperature exceeded the optimum temperature was smallest (2.71 hours) for this farm and coincided with the highest yield (16 bales/ha^{-1}) among the participating farmers whose data was used in this evaluation.

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SPECIAL THANKS TO OUR CONTRIBUTORS