Australian Government

Cotton Research and Development Corporation

SUMMER SCHOLARSHIP REPORT: 2014-15 SEASON

1. **Project Title** : Impacts of biodegradable plastic mulch on cotton crops in southern New South Wales (US1504).

2. **Proposed Start Date** : 1/11/14
Proposed Cease Date : 1/11/15

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4. **Organisation & Location for the project** : The University of Sydney, Griffith and Camperdown.

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SUMMER SCHOLARSHIP REPORT

(Maximum FOUR pages)

1. Executive Summary: This research project was a pilot study involving four trial sites in the Riverina region of New South Wales comparing establishment, growth rates, plant maturity and yield between cotton crops grown under a plastic film mulch and conventionally grown cotton. It was hypothesized that crops grown under plastic mulch will have better establishment, increased growth rates and earlier maturity with no loss of yield.

Sporadic significance was found across trial sites when comparing establishment and yield, with establishment typically lower (6.2%) when grown under plastic and the most significant increase in yield found at one farm equating to a 2.8 bale/ha increase under plastic mulch. Overall trends however suggest there is potential for some benefit in using plastic film mulch on cotton crops in this region in terms of improving growth rate and maturity. Both node production and reduction in nodes above white flower occurred earlier and faster in all crops grown under plastic. This should be the focus of more detailed study.

2.Background: Cotton growers in southern New South Wales struggle to relate research from other cotton growing regions to their own farm management systems. Difficulties with crop establishment due to the cooler start of the season in this region has been identified as an issue that needs to be addressed. The concept of using biodegradable plastic film as a mulch to create a microclimate for geminating seeds has sparked interest among industry members.

3.Aims and Objectives: The aims of this project were to assess the effects of using biodegradable plastic mulch on cotton establishment, growth rates, time to maturity and yield in southern New South Wales as well as identifying any possible water saving potential. The project also aimed to address the economic viability of this new management strategy to aid in growers' future decisions in adopting the technique.

4.Materials and Methods: Four sites were selected across three properties between Griffith and Hay. All treatments were arranged in a randomised block design with one replicate and a control, and between 5 to 10 sub-samples per plot. An edging buffer of 24 rows (four passes of a 6-row cotton picker) was left on the edge of the fields.

Daisy Lodge (south of Carrathool) hosted two sites, of 2 and 3 hectares respectively.
Birra-Li (southwest of Griffith) hosted one 25 m^2 site.
Point Farms (southwest of Darlington Point) hosted one 35 m^2 site.

The two sites at Daisy Lodge had plastic laid by a specially designed and made implement that required an extra tractor pass immediately post-sowing. The two smaller sites at Birra-Li and Point Farms were laid by hand with a single roll of plastic and soil was shovelled to weigh down the edges.

Throughout the summer growing period, all trial sites were managed to the growers' and agronomists' requests, to best manage the uncovered crop. Physiological plant features were recorded periodically throughout the season to determine growth rates. Establishment was determined by counting the number of plants per metre as the crop emerged, and until the crop was well established. A random sample of 5 individual metres was selected and the number of plants in each metre counted and recorded. Establishment of the crops was determined by counting the number of plants per metre compared with the sowing rate per metre. A percentage outcome was calculated, along with standard errors as an indicator of consistency throughout the crop. Nodes and plant height were recorded by randomly selecting 10 plants in each plot and counting the number of nodes on each. To compare growth rates the number of days taken for each plot to reach sixteen nodes was calculated from the trendline equation, and the number of days taken to reach this point between crop under plastic and uncovered crop was calculated. Plant maturity was determined by flowering and nodes above white flower (NAWF), which were counted weekly from the onset of flowering. Ten plants were randomly selected in each plot and the nodes above the most recently open white flower were counted and recorded.

Yield was estimated by hand picking samples at all four sites. This involved removing the lint and seed from every open boll on each plant in a 1 m section. Three replicates were taken from each trial and corresponding control.

These samples were then delivered to Cotton Seed Distributors in Wee Waa where they were ginned and weighed with the lint and seed separated. Data was collated as necessary and analysed where appropriate.

JMP Pro 9 was used along with Microsoft Excel 2013 to statistically compare establishment and yield data. ANOVA was used to compare treatments over all sites as well as sites with each other. Student's t-test was used for assessing treatment impacts individually within each trial site. Growth rate and maturity were analysed using trendlines and standard errors calculated using Microsoft Excel 2013.

A cost benefit analysis of the 2014/15 season grown in the best practice management system was calculated using information from the New South Wales Department of Primary Industries Gross Margin template for irrigated cotton in southern New South Wales.

The gross margin formed above was modified to calculate a cost benefit analysis of the current situation in the experiment, including the cost of the plastic, labour hours, differences in yield and water saving potential for the 2014-

2015 season was made to determine whether this new management system could be adopted in an economically viable way.

The same gross margin was modified to calculate a cost benefit analysis that included a reduced cost of plastic and reduced labour hours through efficiency such as when the implement could be towed directly behind the seeder.

5.Results:
A difference in establishment was recorded between sites, but only one site had a difference between treatments.

Table1. Establishment mean numbers comparison by a) treatment, and b) trial site. Levels not connected by the same letter are significantly different. (Standard error).

a)

Treatment	Mean
Control	65.1 (4.34)[a]
Plastic	58.9 (4.34)[a]

b)

Trial Site	Mean Control	Mean Plastic
Daisy Lodge F3	68.8 (2.9)	68.8 (2.9)
Daisy Lodge F18	39.6 (5.3)	43.8 (0.0)
Point Farms	83.3 (17.3)	75.0 (5.1)
Birra-Li	71.3 (2.9)	45 (5.4)

The number of days taken for the crops to reach 16 nodes was faster when grown under plastic at all trial sites. Growth to this point (ie vegetative crop growth) was faster by 3 to 9 days.

Table 2. Number of days taken for plants to reach 16 nodes, the standard for first flower appearance, and the difference in number of days between the control and plastic covered crops.

Farm	Control	Plastic	Difference
Daisy Lodge F3	69.8	61.3	8.5
Daisy Lodge F18	90.2	87.1	3.1
Point Farms	79.9	74.6	5.3
Birra-Li	77.9	75.0	2.9

Plant maturity was faster in all crops grown under plastic than those grown conventionally. The plastic reduced time taken to reach 4 nodes above white flower (NAWF) by 2 to 10 days and it is interesting to note the uncovered control at the Birra-Li site, the flowers did not appear until 103 days post sowing, 24 days after the plastic covered trial.

Table3. Number of days taken for plants to reach 4 nodes above white flower, the standard for plants to begin natural cut-out, and the difference in number of days between the control and plastic covered crops.

Farm	Control	Plastic	Difference
Daisy Lodge F3	111.1	-	-
Daisy Lodge F18	136.2	126.4	9.8
Point Farms	113.8	111.7	2.1
Birra-Li	122.7	116.5	6.2

Yield means for the treatments at each farm were compared using a t-test to identify any differences within the trial sites. There were no significant differences found between treatments at the farm level (Table 4).

Table 4. Yield means comparison by a) treatment, and b) trial site. Different letters indicate significant difference. Levels not connected by the same letter are significantly different. (Standard error).

a)

Treatment	Mean

Control	13.5 (0.53)^a
Plastic	12.8 (0.53)^a

b)

Trial Site	Mean Control	Mean Plastic
Daisy Lodge F3	10.6 (0.4)^c	11.5 (0.7)^c
Daisy Lodge F18	11.4 (1.0)^c	11.2 (1.4)^c
Point Farms	15.2 (0.9)^a	18.0 (0.5)^a
Birra-Li	13.8 (0.4)^b	13.3 (1.0)^b

Soil moisture was recorded daily with moisture probes at Daisy Lodge Field 18. The total water saving potential of using plastic is estimated in Table 5. (Data courtesy of Michael Braunack, CSIRO.)

Table 5. Calculations of water saving potential in cotton grown under plastic compared with an uncovered crop.

Total water saving (mm)	73.66
Average per irrigation (mm)	8.25
Approximate number of equivalent days	3

Average days per cycle	14.8
Irrigations per season	9

Number of days saved	27
Number of irrigations saved	1.8

A standard gross margin budget for irrigated cotton in southern New South Wales showed an expected profit of $4306 /ha, given a yield of 13.5 bales/ha (average number of bales produced in control plots of this project). This budget also assumes the price of cotton and cotton seed, as well as using 9.5 ML of water per hectare. This was altered to include the current cost of integrating the plastic into the farming system and also a ‘best-case scenario’ including the highest mean yield found under plastic, a 1.8 ML/ha reduction in water use and a severely reduced cost of buying and laying the plastic.

Table 6. Gross margins found for three modelled scenarios.

Scenario	Gross Margin ($/ha)
Conventional	4306.34
With plastic in 2014/15 season	3630.81
With plastic best case scenario	6697.66

6. Discussion and Conclusions: The establishment of cotton under plastic was poorer than it was when grown conventionally. The theory behind the plastic mulch suggests that the increased soil temperatures of 2-4˚C and higher moisture content (Braunack *et al*. 2015) would improve seed viability and allow a stronger and more densely populated crop. Where the plastic was laid there was extra cultivation of the seed bed and a physical barrier either side of the seed line, it could have reduced the number of volunteer plants and seeds skewed from the planting line establishing in the plastic trial areas. This could be the reason for the differences observed in establishment and why the results were not as predicted, or because as the seed bed was disturbed by laying the plastic the seeds could have sunk to a depth from which they could not emerge.

The time taken to reach 16 nodes was extrapolated from the trendline, making it difficult to compare means. The growth rates were initially faster under plastic, and by the end of crop development half of the control trials had caught up. Although there was not a large difference in growth rate between the trial and control plots, it supports the hypothesis that early growth rates would be increased due to the microclimate formed underneath the plastic. The growth stage of 16 nodes was chosen to compare the covered and uncovered crops because it is at sixteen nodes that the plant will typically begin to flower, and the growth rate reduces from 2.5 nodes per week down to anywhere as low as 1 node per week (Powell 2011, Scott and Powell 2011, H. McWhirter, personal communications, 21 Oct 2015).

Four nodes above white flower (NAWF) was used to measure plant maturity and was extrapolated from trendlines. These trends were compared at four nodes above white flower because this is when the plant will begin to cut-out naturally and put more energy into boll filling, rather than producing new bolls (Powell 2011, Scott and Powell 2011, H. McWhirter, personal communications, 21 Oct 2015). The trendline for the plastic trial at Daisy Lodge Field 3 could not be solved for four nodes above white flower, because after the appearance of the first flowers there was a rainfall event, followed by a series of warm days that caused the plant to switch back to vegetative growth. The nodes above white flower then decreased as expected, however they then plateaued in this case, causing the trendline to be a less accurate indicator of the actual plant development. This early natural cut-out could mean an earlier crop can be picked, or that less Mepiquat chloride would be required to regulate the growth of the plant in the later stages of the season.

This project was not aiming to calculate the water saving potential of using biodegradable plastic film in cotton production, however some data was included as an indication of the use of water in crops under plastic and uncovered crops. The soil profile under plastic had an average of 8.25 mm more water than the uncovered crop on the last day of each irrigation cycle. This equates to approximately 3 days' worth of water usage. Assuming that each irrigation could be pushed back an extra three days, and an average of nine irrigations per season, this would allow for 27 days' worth of water being saved. This is equivalent to 1.8 irrigations at approximately 1 ML each, saving a total potential of 1.8 ML per plastic covered hectare per season.

Determining the economic viability of including this plastic film into a management system was one of the key aims of this research project. The plastic costs $317 /ha, plus labour costs at $22 /hour at an average laying rate of 1.7 hrs/ha is $37.40 /ha per person (at least 2 people are required to lay the plastic) and an estimated tractor operating cost of $36.74 /hr. The water saving potential has been estimated at 1.8 ML/ha throughout the season, whether this be through fewer irrigations or less water being used each time. At the DPI stated water price of $47.15 /ML, there is a potential saving of $84.87 /ha. Minus this from the total increase in costs to see an increase in the total variable costs by $343.67 /ha. This amount could be offset by the total income on the crop if the yield increased by 1.3 bales/ha. However an increase as great as this was only found in one of the four trial sites (Point Farms yield increased 2.8 bales/ha under plastic). The average yield income from all four sites was used as a benchmark for yield under plastic in this model making the total profits $3631 /ha. Less than the conventionally grown cotton, however this estimate does not take into account the other potential benefits of the plastic, including the ability to stagger planting times to make timings of operations such as planting and picking easier at the end of the season, when there is limited access to the machinery required but also a need for timeliness.

The gross margin was then altered further to demonstrate a highly reduced cost of using the plastic. This gross margin assumed a reduction in the cost of plastic up to two thirds, and also completely eliminating the extra labour requirements assuming the implement will eventually be able to attach to the seeder and lay the plastic in the same pass as planting. The same amount of water saving was assumed making the increase in total variable costs $105.67. The total income was also increased to the maximum average yield of cotton under plastic (18 bales/ha at Point Farms). This lower cost of production and higher income gave a final gross margin of $6698 /ha.

It is important to consider that this is an absolute best case scenario, and margins as great as this were not found in any of these preliminary trials in this research project. Each farm is different and it is expected that yields, inputs and uncontrollable factors at each property will impact on the gross margin. Even if the gross margin does not increase substantially or at all, there could still be some benefit of including the plastic into a cotton production system. The potential for water saving is crucial, particularly in a drought year or when water allocations are low or fluctuating. This could provide a grower with more security in terms of water available and the amount of land able to be confidently planted.

The plastic also has the potential to stagger planting. Crops could be sown earlier, knowing that the soil temperature will remain 2-4˚C warmer than uncovered soil, allowing for an extended season with more growth and higher yield potential, although yield potential of cotton is estimated to be 19 bales/ha (Constable and Bange 2006). On the other hand, crops could be planted later under plastic and emergence times would be faster, as well as having a faster growth rate such that the crop would still be able to grow effectively to a size where yield may not be impeded as heavily as an uncovered late crop.

7.Highlights: The greatest highlight from this experiment is the water saving potential offered by using the plastic in a cotton production system. Having the ability to reduce the need for 1.8 irrigations would save approximately 2 megalitres of water per hectare of crop. Another highlight would be the consistency of growth across the fields as well as reducing the time taken for plants to reach maturity. This could help growers manage their crops more efficiently, saving them time and money.

8.Future Research: A more thorough experiment would be the next step here, also considering the temperature under the plastic and using crops from multiple seasons to gain a better idea of how the crop might be affected. The economic viability and overall potential of the plastic could be discovered by managing the crop to the crop covered by plastic, rather than the uncovered control crop.

9.Presentations and Public Relations: This work was presented at The University of Sydney's Stepping Out With Fresh Ideas (SOWFI) conference in November 2015.

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