Australian Government
Cotton Research and Development Corporation

FINAL REPORT 2013

Part 1 - Summary Details

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

CRDC Project Number: **CSP1306**

Project Title: The potential for biodegradable film to improve cotton establishment in cool regions

Project Commencement Date: 1/07/2012 **Project Completion Date:** 30/06/2013

CRDC Program: Farming Systems

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Signature of Research Provider Representative: _____

Part 3 – Final Report

(The points below are to be used as a guideline when completing your final report.)

Background

1. Outline the background to the project.

   Poor crop establishment compromises productivity and may necessitate the expense of replanting. In cool regions, production can be limited by the need to replant due to prolonged cold conditions. New biodegradable thin films provide an opportunity to overcome this limitation without the risk of contaminating lint at harvest. The concept is to plant cotton and apply film in one pass, with the film degrading as cotton emerges so the crop grows as if planted with no film. Preliminary results suggest the films enhance early establishment however, the film used did not breakdown as expected. Pilot studies undertaken in the Namoi Valley has demonstrated that thin film promoted early and uniform crop emergence by increasing soil temperature and retaining seedbed moisture compared to bare soil. Following emergence cotton was not able to penetrate the film due to excessive temperatures under the film, therefore crop growth and yield benefits have not been determined.

Objectives

2. List the project objectives and the extent to which these have been achieved.

   The project will investigate the potential of thin film for early planting in southern NSW and to conserve water in other areas.

   This objective has been achieved.

Methods

3. Detail the methodology and justify the methodology used. Include any discoveries in methods that may benefit other related research.

   Time of planting experiments were established at the Australian Cotton Research Institute (ACRI) and three sites near Griffith to determine the effect of row orientation, and to compare thin biodegradable film covered areas with the current system on crop emergence, establishment, development, yield, and fibre quality. Treatments included bare surface and two plastics (P1 and P2, P1 is a starch based thin film while P2 is an oxo-degradable thin film, both films degrade at different rates) currently available in Australia. P1 becomes opaque as it degrades while P2 remains clear. Four replicates of each treatment were arranged in strips 5m long in three adjacent rows of 1 m cotton. Temperature and soil water potential was monitored every three hours at planting depth (0.05 m) from sowing to crop establishment. Crop establishment was monitored on a regular basis and yield and quality parameters were determined from hand picks in 1 m length of row from areas with uniform plant population. Crops were managed by cooperating growers. One site at Griffith was abandoned prior to monitoring crop development due to excessive weed growth.

   Plots were planted on 24th September, 2nd October and 18th October 2012 at ACRI. Sicot 71BRF was planted at 0.05 m and plots were irrigated on 5th October 2012. The thin film was slit on 3rd October, 14th October and 1st November 2012 to enable the emerged seedlings to continue growing. The experimental area was irrigated again on 2nd November 2012.

   Three sites were established near Griffith in southern NSW: Sites 1 and 2 were located on a De Bortoli wines property with Site 1 having east-west row orientation and Site 2 had north-south row orientation and Site 3 on the property "Bundarra" having east-west row

orientation. Site 3 was abandoned for maturity picks due poor establishment and excessive weed growth. Sites 1 and 2 were planted with Sicot 71BRF on 3rd October, 2012, while site 3 was planted with Sicot 74BRF on 9th October 2012. Cotton was planted dry at 2 cm depth at all sites. Sites 1 and 2 were approximately 200 m apart.

At both sites the trial layout at each site consisted of 4 replicates with 3 row plots. Treatments were Plastic 1 (P1), Plastic 2 (P2) and Control (No plastic). Each plot was 5 m long by 3 adjacent rows 1 m apart for each treatment; bare, P1 and P2, except for the monitoring plot which consisted of each treatment in three adjacent rows (one bare row, one row with P1 and one row of P2). This was to facilitate the placement of logging equipment and to restrict the spread of sensor leads across the field for normal operations to continue. A combined temperature and ceramic water potential sensor was placed at the planting depth (0.05 m) under each treatment at each planting time prior to placing the film over the row for each site.

Once cotton was sown the film was rolled over the hill and edges buried securing the film (Photo 1). This was difficult to achieve under windy conditions. The final layout for each field site is shown in photo 2.

Photo 1

Photo 2

Site 1 was irrigated on 12th Oct., Site 2 irrigated on 7th Oct. and site 3 was irrigated on 15th Oct. 2012.
The film was slit on 23rd, 17th and 26th October 2012 at sites 1, 2 and 3 respectively to enable the emerged cotton to continue growing.

Data was analysed using Genstat 14 (VSNI, 2012) as a random block design ANOVA with $P < 0.05$ for significance.

Results

4. Detail and discuss the results for each objective including the statistical analysis of results.

ACRI planting date:

Soil temperature at sowing was lower for sowing one and increased with each subsequent sowing date (Fig 1). Both thin films (P1, P2) elevated soil temperature at the planting depth compared with the control, with the differential averaging five degrees until the film was slit when the temperatures converged (Fig 1). The P2 film tended to maintain higher temperatures at all sowing times until the film was slit to allow emerged seedlings to continue growing (Fig 1 a, b, c). The P2 film remained clear as it degraded compared with P1 which tended to become opaque (Photo 6, 7 and 8) which contributed to the higher temperatures. It was not possible to statistically analyse the data due to insufficient equipment to undertake replicate measurements.

Soil water potential at the planting depth varied between sowing times (Fig 2 a, b, c) largely due to when the site was irrigated. The two thin films maintained a lower soil water potential (the less negative the reading the wetter the soil) than the control from planting until the first irrigation for sowing one (Fig 2 a). Soil at the planting depth remained wet under all treatments until the film was slit as the site had been irrigated three days prior to planting (Fig 2 b). After the film was slit the P2 film maintained higher soil moisture compared with the other treatments although all were drying down (Fig 2 b). After planting sowing three the soil at planting depth dried considerably while the soil under the film, especially P1, remained wetter until irrigation (Fig 2 c, LH graph); after the irrigation all treatments re-wet and dried at a similar rate (Fig 2 c, RH graph).

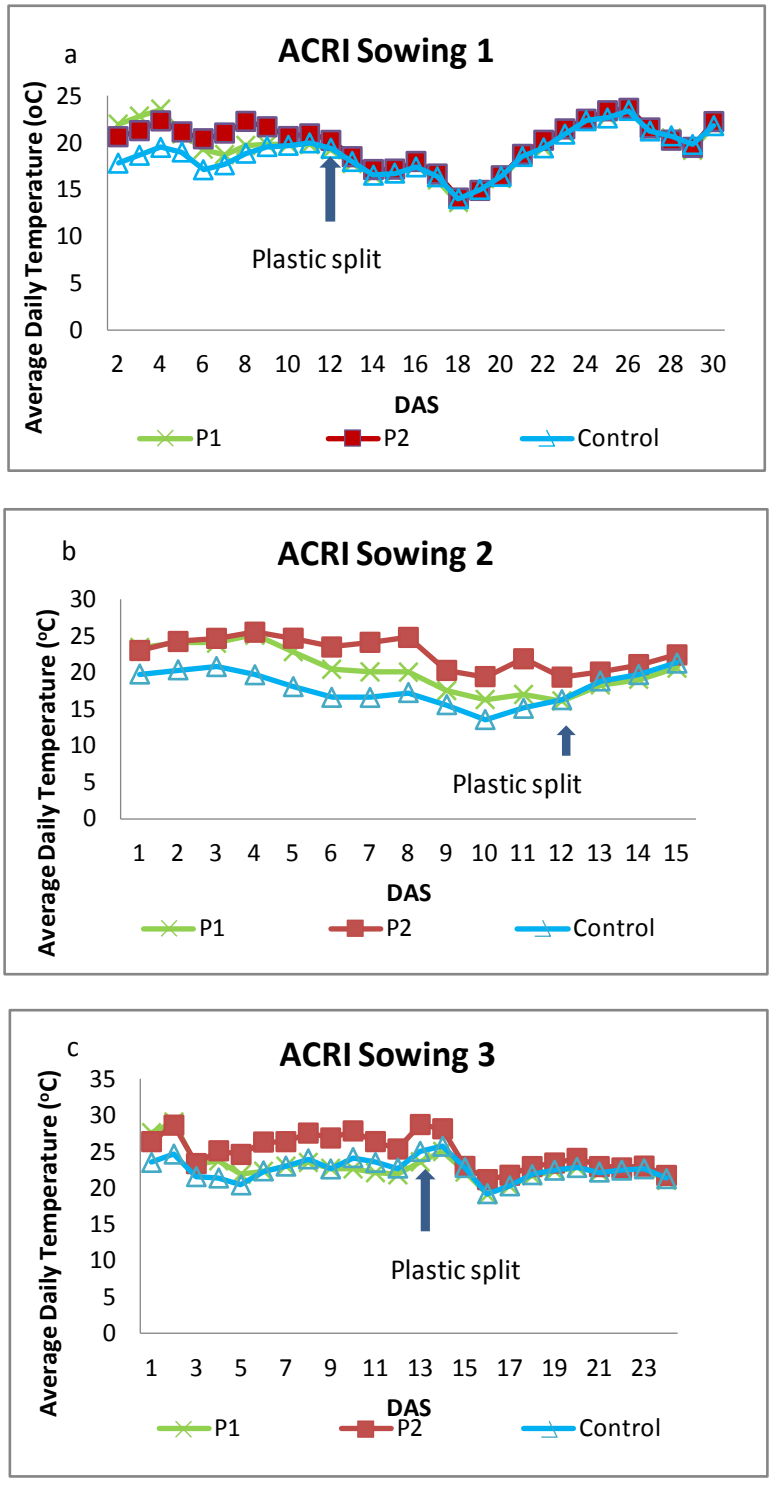


Figure 1Soil temperature at sowing depth (0.05 m) for(a) sowing 1,(b) sowing 2 and (c) sowing 3 at ACRI

The films were split to allow emerged cotton to continue growing which occurred prior to the irrigation.

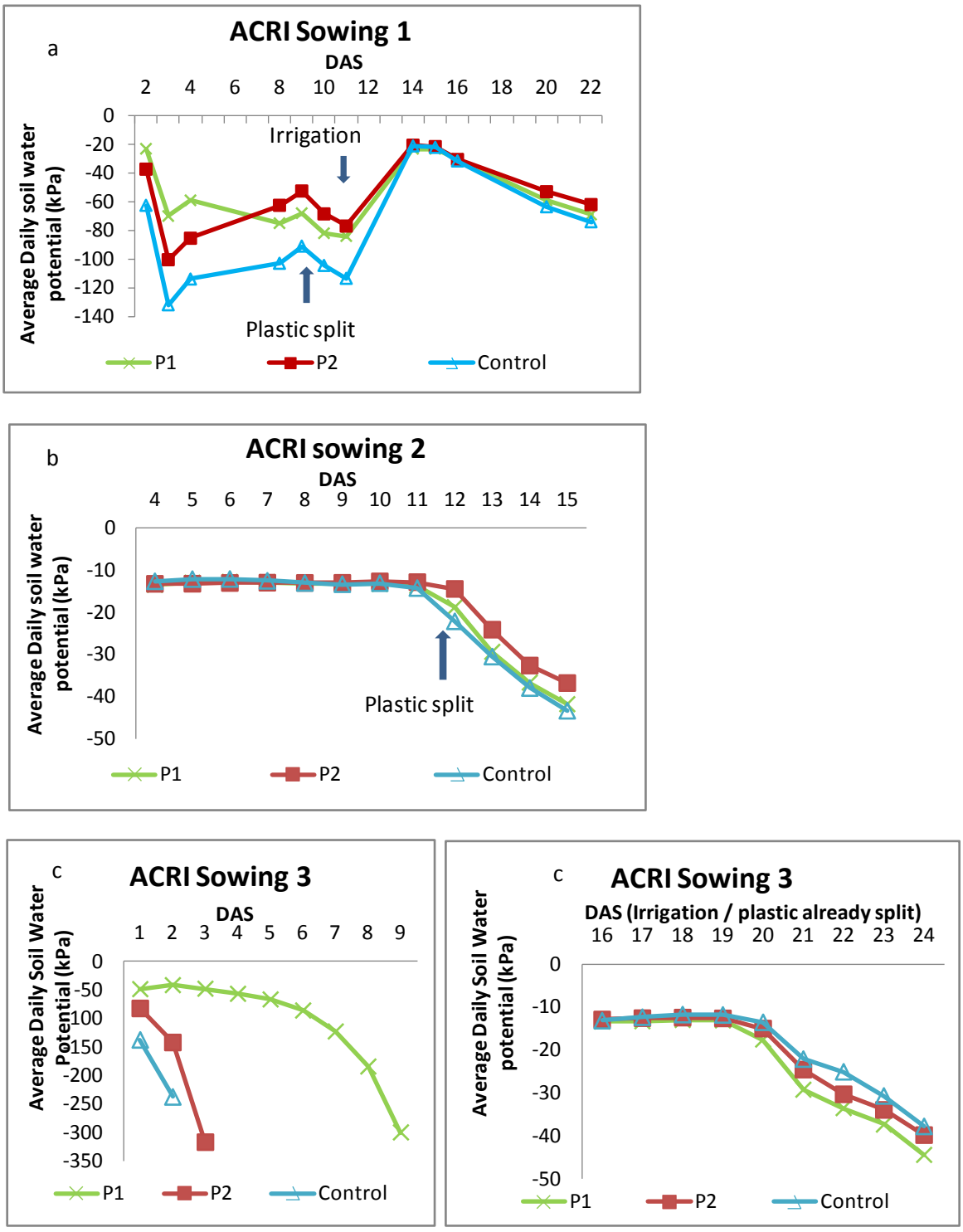


Figure 2 Soil water potential at sowing depth (0.05 m) for (a) sowing 1, (b) sowing 2 and (c) sowing 3 at ACRI (logger failure resulted in intermittent data for sowing 3 as the profile dried LH graph, replacement logger after irrigation RH graph)

Crop establishment varied between treatments with a significant treatment by DAS interaction between 10 and 14 DAS ($P < 0.001$) (Fig 3). Final establishment for each sowing time was similar for all treatments except for P2 at sowing three (Fig 3 c) which was significantly lower due to not slitting the film at the appropriate time. Establishment

occurred more rapidly under the film compared with the control (Fig 3 a, b, c) which agrees with the elevated soil temperatures and higher soil moistures above. Establishment under the film was on average 5 -7 days earlier than the control. The main problem in using thin film was the inability of emerging cotton to penetrate the film, necessitating splitting the film to enable the seedlings to continue to grow. The head space temperature built-up rapidly under P2 which had not begun to degrade resulting in seedling death, while P1 was degrading at the same time allowing seedlings to survive (Fig 3 c). This was the result of the late plant date where temperatures were rising.

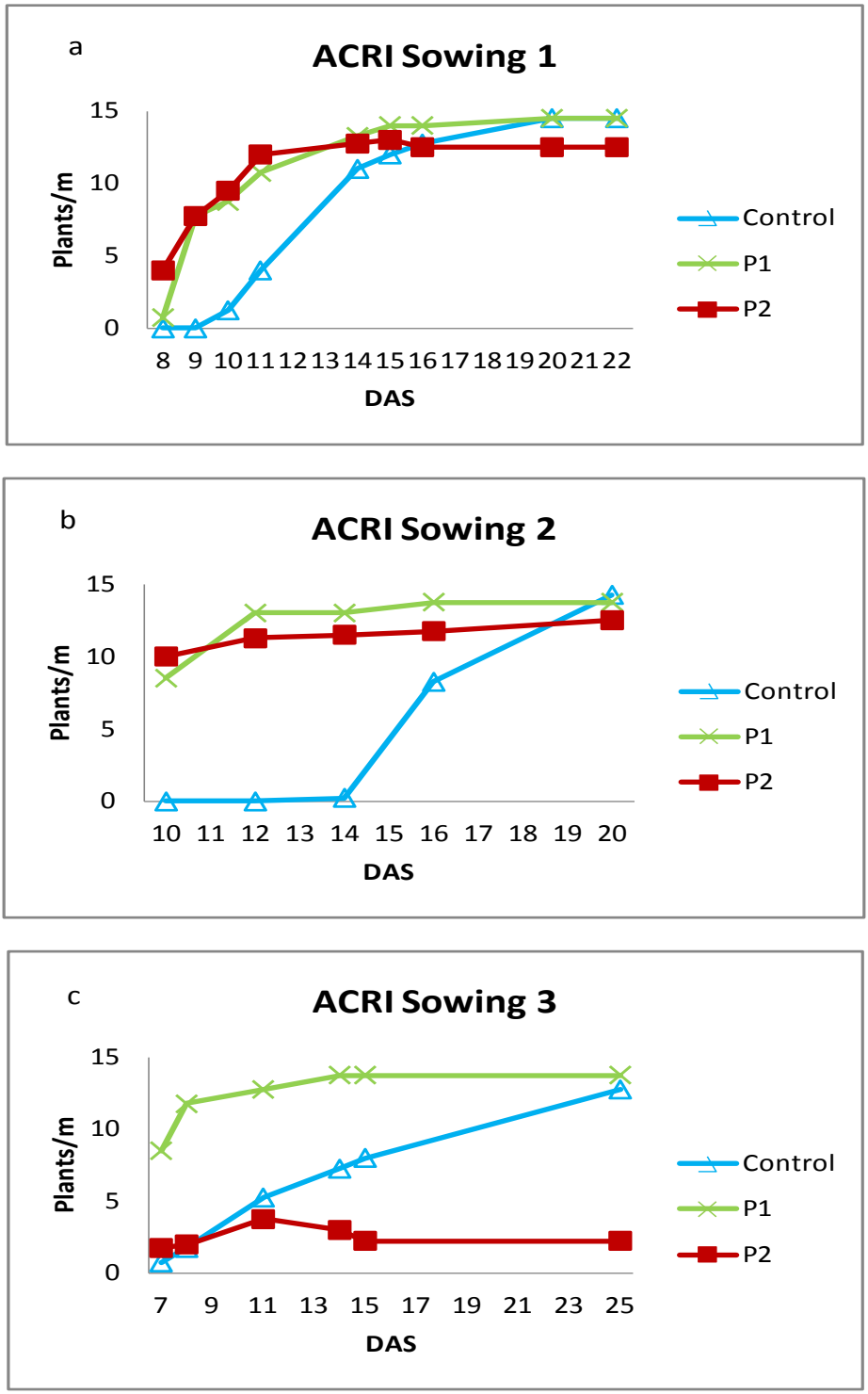


Figure 3 Crop establishment for (a) sowing 1, (b) sowing 2 and (c) sowing 3 at ACRI

There was no significant difference between treatments for both plant height and number of nodes (Fig 4). However, there was a significant difference between sowing times in plant height and number of nodes, with sowing 2 having significantly more nodes and sowing 3 significantly higher plants (Fig 4).

Lint yield was determined from hand picks so will be greater than that from machine picking. Also, very low crop establishment under P2 for sowing 3 resulted in a similar lint yield to that for the other treatments indicating large compensation through total boll number. There was no significant difference in lint yield between treatments and sowing times (Fig 5). Samples are still being processed for fibre quality.

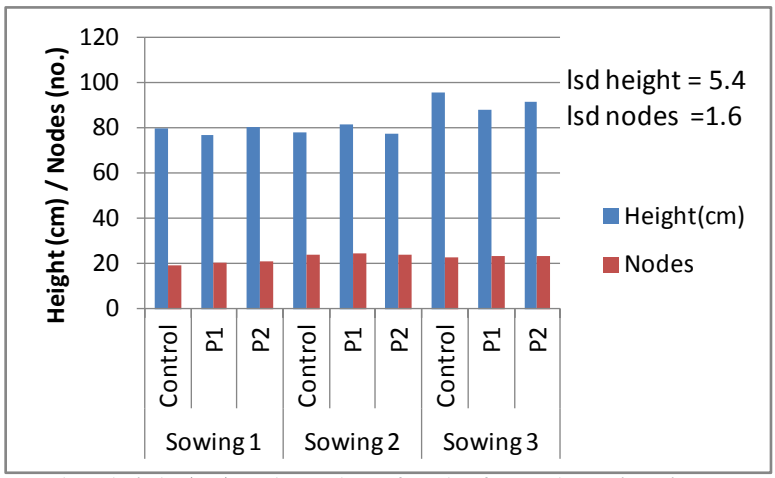


Figure 4 Plant height (cm) and number of nodes foe each sowing time at ACRI

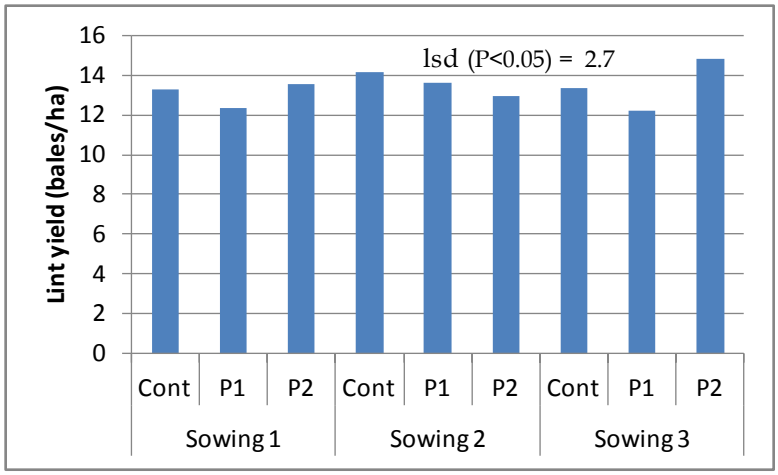


Figure 5 Lint yield (bales/ha) for each treatment and sowing time at ACRI

Griffith row orientation:

Soil temperatures were elevated and soil water potential was lower (soil was wetter, less negative values) under the film compared with the bare soil at each site (Fig 6). Soil temperature was greater than 15 ^{o}C at sowing for all sites.
Average daily soil temperature was elevated by 1-4, 3-5 and 1-4 ^{o}C under the film compared with bare soil at sites 1, 2 and 3 respectively. The higher temperatures occurred with north- south rows (site 2) compared with east-west rows (site 1). The temperatures under P2 tended to be greater than under P1.

At all sites up until the film was slit the soil water potential was within the range -10 to -50 kPa. Plant roots are able to extract sufficient water at soil water potentials between -10 and -60 kPa for growth. The bare plots continued to dry while the film covered plots maintained soil water: once the film was slit, the film covered plots retained moisture for longer as film protected the sides of the hills reducing evapotranspiration from the soil while the bare soil plots dried rapidly.

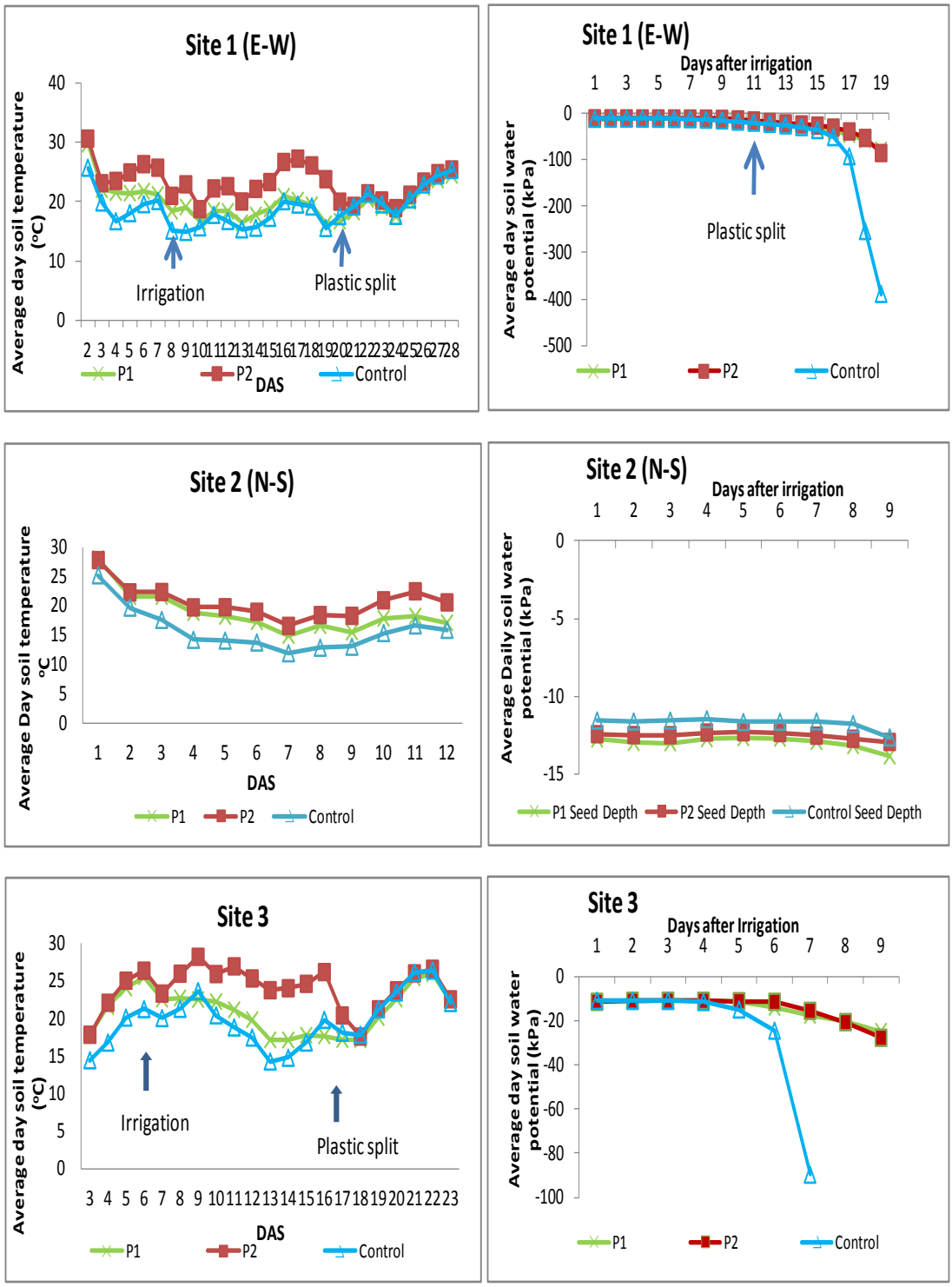


Figure 6 Soil temperature and soil water potential at the sowing depth (0.05 m) for each site near Griffith (Site 3 E-W)

The logger at site 2 failed after 12 days and no data was collected from that time on. Until logger failure all treatments were similar and soil water would not have limited emergence.

After slitting the film it rapidly degraded and disappeared from the surface, however buried film had not degraded (Photo 3). Contamination of cotton by the film at picking will pose no risk as there is no exposed film on the soil surface (Photo 4).

Photo 3

Photo 4

Seedbed conditions at each site were similar with site 2 having a finer seedbed condition than the other two sites (Fig 7). This indicates that germination at site 2 would occur sooner, due to better seed soil contact, compared with the other sites, which seems to be the case as emergence occurred at 14 DAS compared with 19 DAS for the other sites (Fig 8). There seems to some interaction between seedbed conditions and film with respect to emergence possibly due to better seed soil contact, elevated soil temperature and conserved soil moisture.

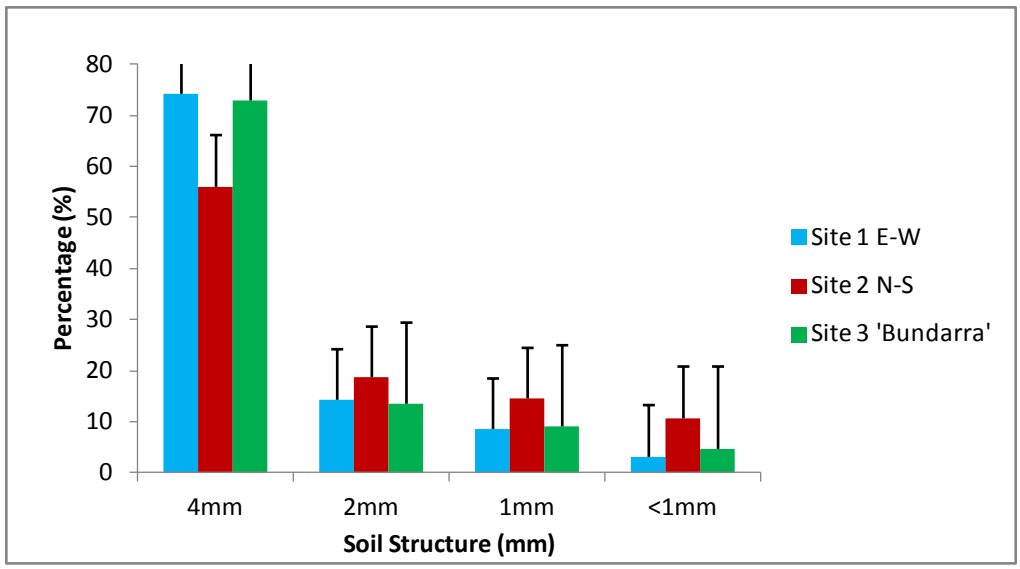


Figure 7 Aggregate size distribution in the seedbed at planting for each site near Griffith (bars are +/- standard error)

Plants emerged slightly earlier, especially on the north-south rows, under the film compared with bare soil at all sites (Fig 8), which reflects the higher soil temperatures at the seed depth under the film. Higher plant establishment resulted on the bare soil at sites 1 and 3; some of the emerged plants desiccated under the plastic before slitting occurred, whereas similar plant populations occurred at site 2 (Fig 8). Plant populations were adequate at sites 1 and 2 and were low at site 3 (Fig 8).

Due to the low plant establishment site 3 has been omitted from the statistical analysis. There was significantly greater establishment from N-S row orientation than E-W rows (8.6 v 6.2 plants per metre, $P = 0.002$) while there was no significant difference between treatments ($P = 0.45$). There was a significant interaction between treatments, row orientation and DAS with higher establishment under P2 with N-S rows from DAS 14 to 20 than under P1 and the control ($P = 0.013$). The difference in establishment had disappeared by 26 DAS except for that between the N-S and E-W rows under P1 and P2 where higher establishment occurred with N-S rows.

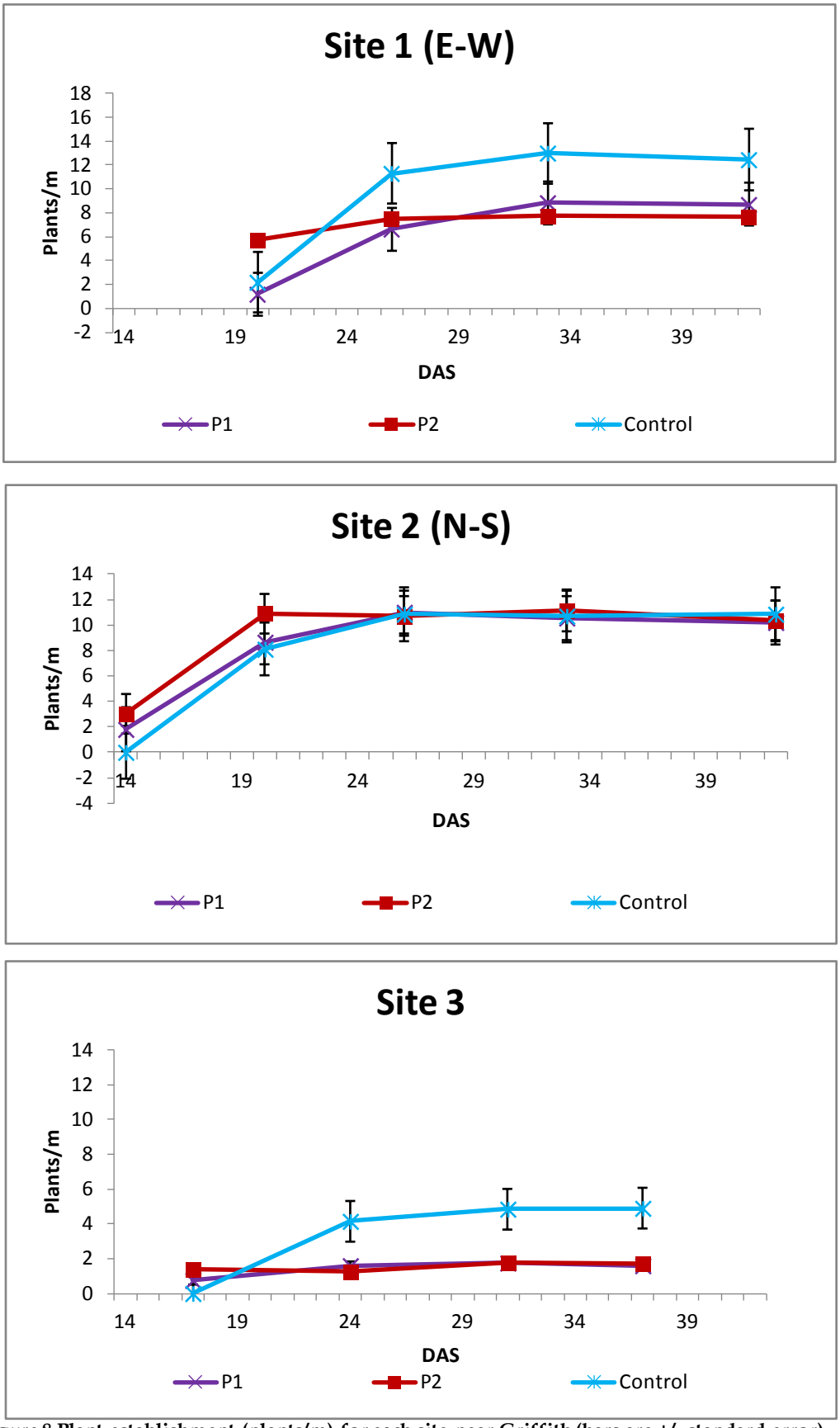


Figure 8 Plant establishment (plants/m) for each site near Griffith (bars are +/- standard error)

Plant height and the number of nodes were similar between treatments at each site, with north-south rows having significantly taller plants and node number compared with east-west (Fig 9). These measurements were not undertaken at site 3.

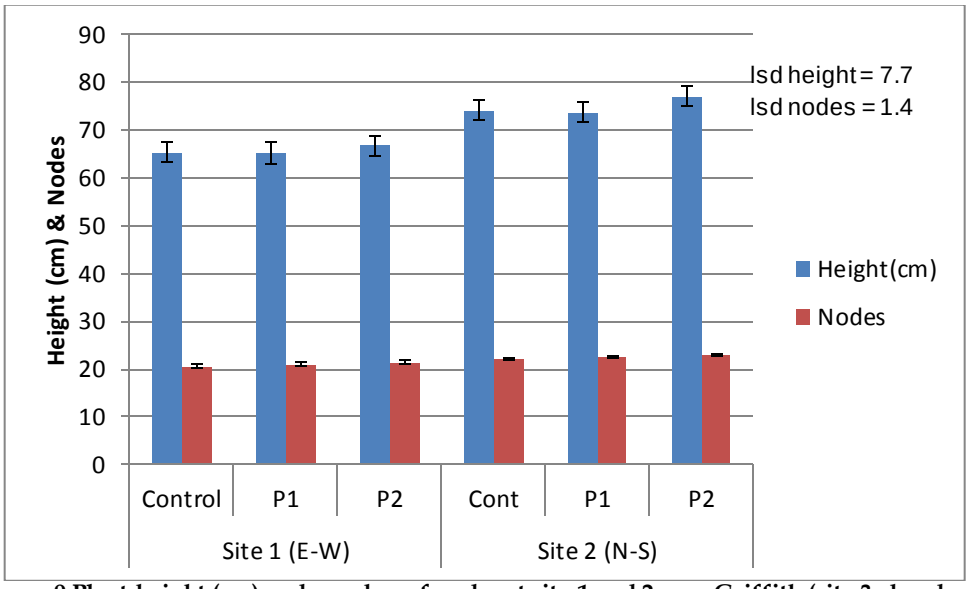


Figure 9 Plant height (cm) and number of nodes at site 1 and 2 near Griffith (site 3 abandoned due to weeds)

Some of the differences may be due to the way that P1 and P2 degrade; P1 goes opaque prior to degrading while P2 remains clear until it begins to degrade. This possibly affects the temperature and moisture conservation under each plastic, certainly the head space temperature under P2 rather than at planting depth in the soil due to the dampening effect of soil. This would make slitting the film at the appropriate time more critical as previous studies showed that head space temperatures could reach 50 ^{o}C.

Maturity picks have been taken and lint yield results are yet to be determined.

Climate analysis:

The analysis indicated the number of cold days and frost days for planting in the first week of September and each week there after for each subsequent month until the last week of November (Fig 10, 11 and 12). There was one exception to this; Emerald where interest is in manipulating planting to avoid wet conditions at harvest so planting was considered from July to November (Fig 10). Subsequent simulation looked at lint yield and the number of failed crops for each planting time.

The analysis indicated that there were a greater number of cold and frost days in September and the number decreased as planting occurred in October to November at all sites in Queensland and NSW (Fig 10, 11 and 12). A similar pattern occurred at Emerald from the earliest plant date in July through to November. The analysis indicates that targeting an early plant date increases the risk of cold shock and frost which would affect crop germination and emergence. The corresponding simulations to determine lint yield and whether the crop survived to final yield also indicates that earlier planting results in a higher number of crops not surviving to maturity, due to frost, and that if the crop survives yield is compromised (Fig 10, 11 and 12). Plant dates in October resulted in the greatest lint yield for all sites (simulated).

The targeted use of thin biodegradable film could potentially mitigate some of the risk in early planting in cool regions. The results above show that by deploying thin film soil temperature can increase by 2 -4 ^{o}C and seedbed moisture is conserved. This results in rapid germination and even establishment compared with bare hills. This benefit is negated by the fact that cotton cannot emerge through the current available thin films necessitating the film to be slit to allow the crop to continue growing.

There are many questions to address; will cotton be able to emerge under thin film that has slots? Will emerged cotton be sufficiently developed to survive a cold period or frost if planted early? Will the fertiliser regime be different under thin film compared with no film? Will irrigation water sub across into the plant line? These and other issues will need further field verification after initial simulation studies. Simulation studies will assist in targeting planting windows that reduce the risk involved with an early plant which may increase season length and save the first irrigation as moisture is conserved under the film. This potentially could increase yield, however, this benefit needs to be balanced against the extra cost of the film. Currently growers take the risk of not experiencing a period of cold weather or frost in planting early the use of thin film may reduce this and reduce the need to re-plant.

The use of thin film is envisaged to only target early planting to reduce the risk of re-plant; however earliness needs to offer a reasonable degree of success for crop survival to maturity. The adoption of thin film will also depend on the economics and perceived benefit.

Photos 6, 7 and 8 provide an indication of film degradation and crop development at various times for the three planting dates at the ACRI. For all plant dates there was no film visible on the soil surface at harvest indicating that contamination will not be a problem. A similar situation occurred at Griffith (Photos 9 and 10). However, at both sites the buried film had not completely degraded although it was brittle.

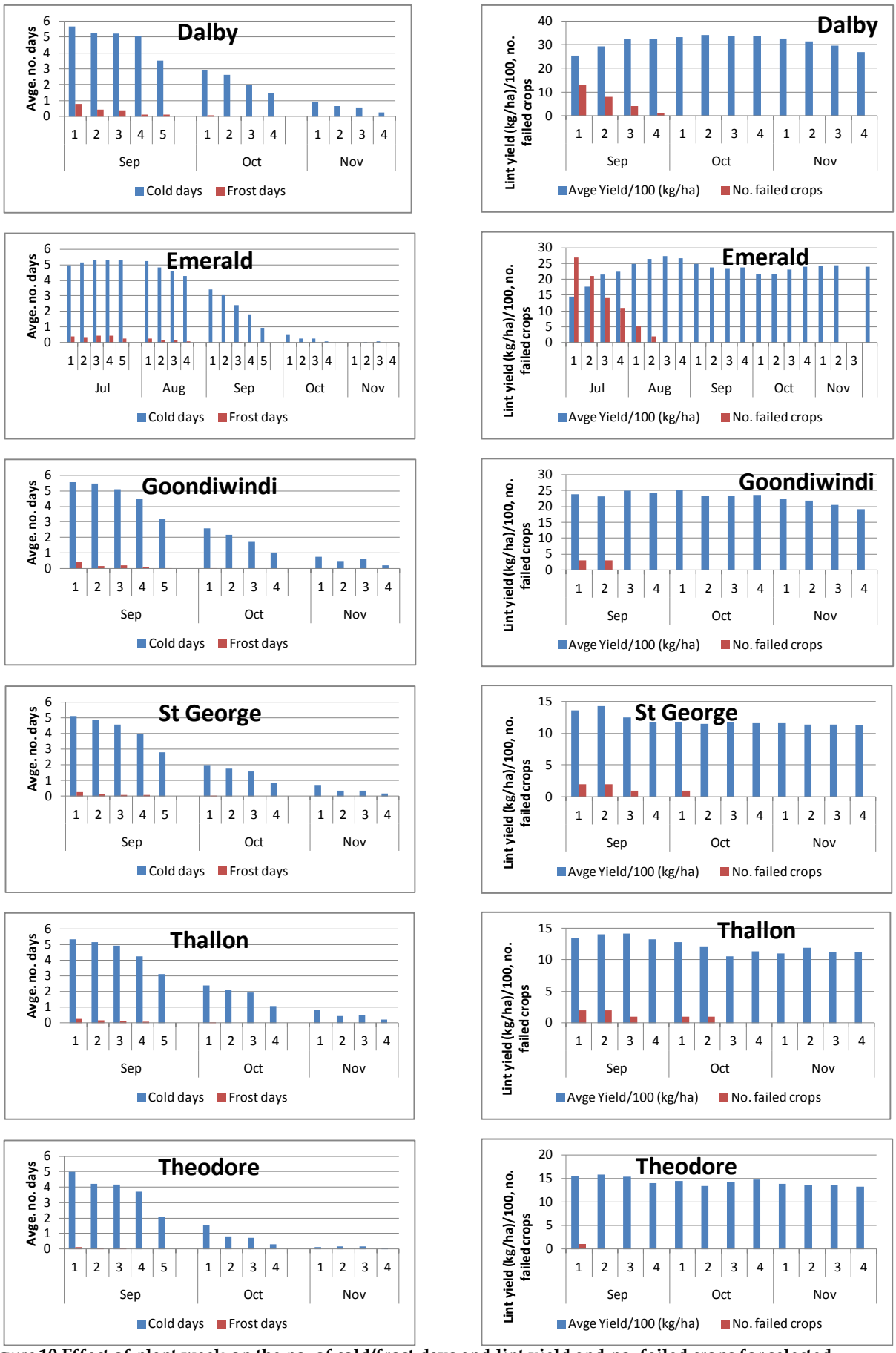


Figure 10 Effect of plant week on the no. of cold/frost days and lint yield and no. failed crops for selected Queensland sites

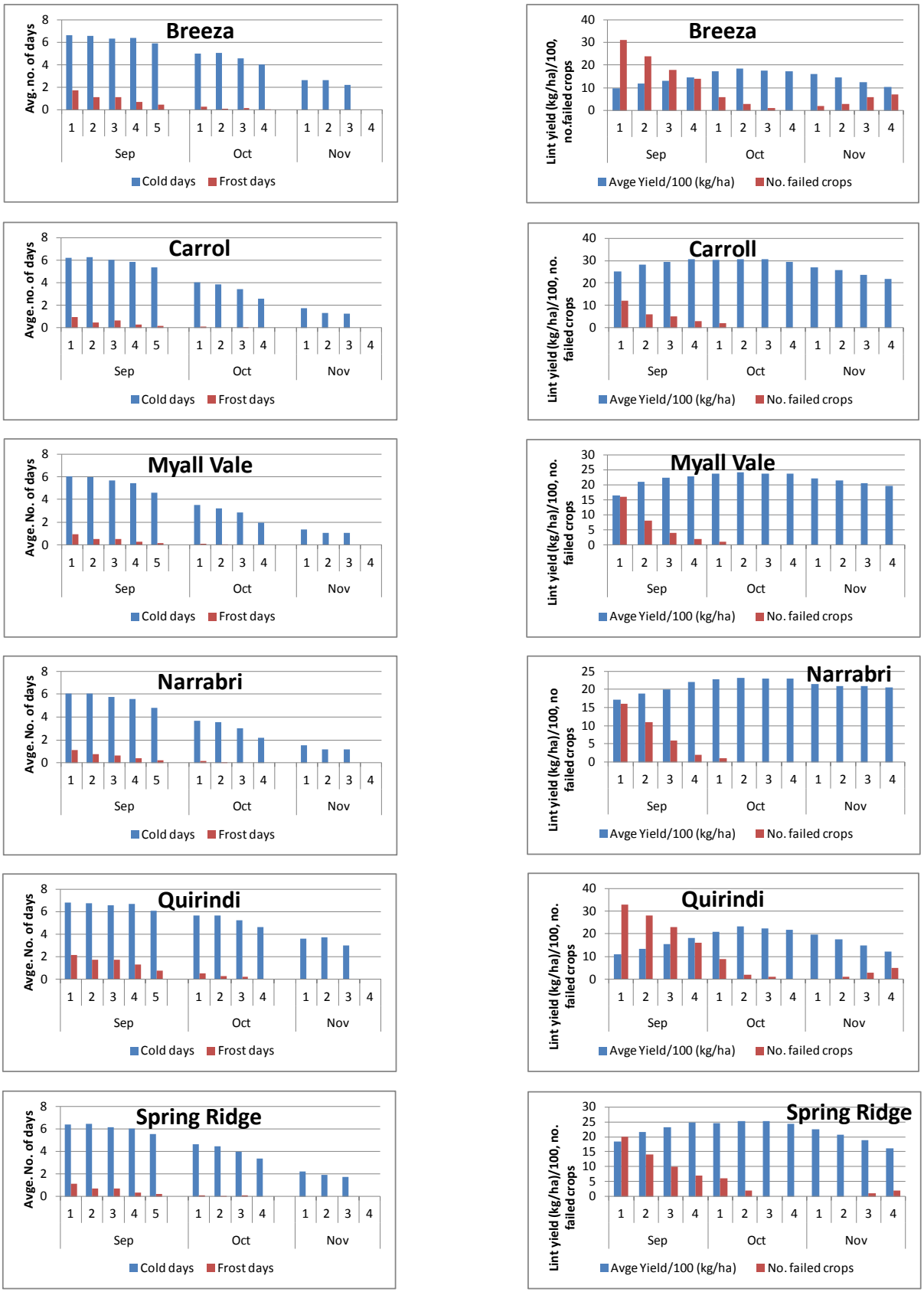


Figure 11 Effect of plant week on the no. of cold/frost days and lint yield and no. failed crops for selected sites in the Namoi Valley, NSW

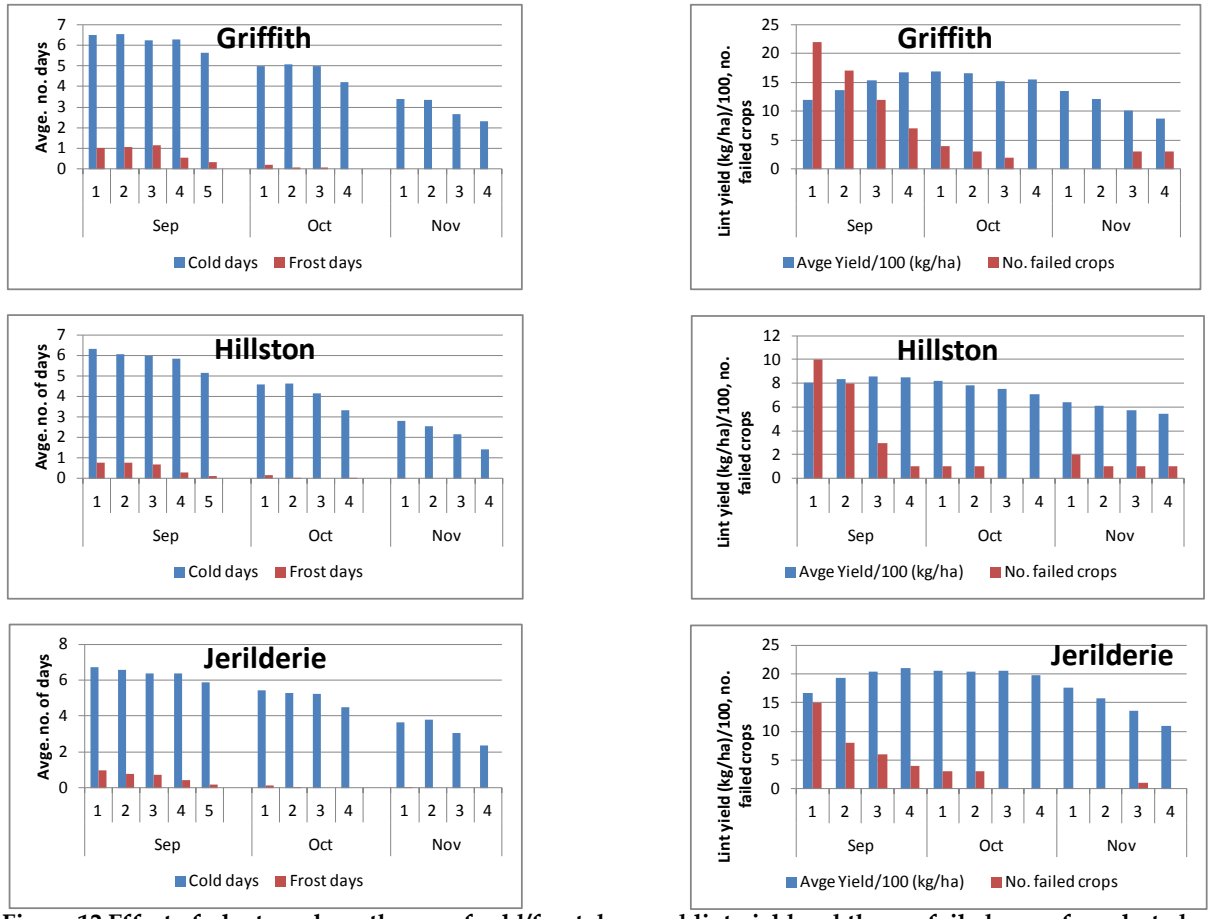


Figure 12 Effect of plant week on the no. of cold/frost days and lint yield and the no. failed crops for selected sites in southern NSW

Photo (series) 6 Thin film degradation and crop development sowing 1 ACRI

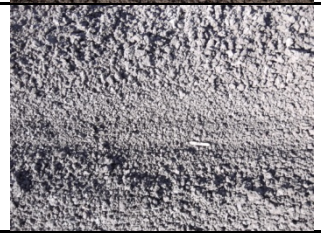
TOS TRIAL 2012 Sowing 1: 24.9.12	DATE 24.9.12	DATE 2.10.12	DATE 8.10.12	DATE 12.11.12	DATE 19.12.12
Plastic 1					
Plastic 2					
CONTROL					
Other					

Photo (series) 7 Thin film degradation and crop development sowing 2 ACRI

TOS TRIAL 2012 Sowing 2: 2.10.12	DATE 8.10.12	DATE 14.10.12	DATE 18.10.12	DATE 12.11.12	DATE 7.12.12
Plastic 1					
Plastic 2					
CONTROL					
Other					

Photo (series) 8 Thin film degradation and crop development sowing 3 ACRI

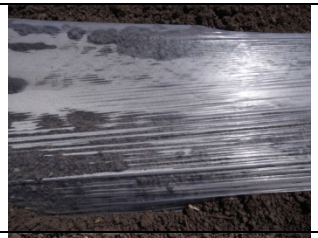
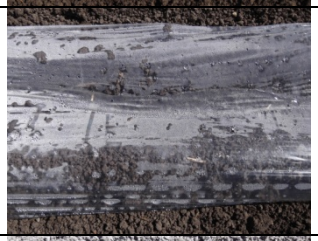
TOS TRIAL 2012 Sowing 3: 18.10.12	DATE 18.10.12	DATE 22.10.12	DATE 25.10.12	DATE 12.11.12	DATE 7.12.12
Plastic 1					
Plastic 2					
CONTROL					
Other					

Photo (series) 9 Thin film degradation and crop development site 1 (E-W rows) Griffith

Griffith TRIAL 2012 Site 1: 4.10.12	DATE 1.11.12	DATE 1.11.12	DATE 12.3.13	DATE 12.3.13 (Film below ground)	DATE
Plastic 1					
Plastic 2					
CONTROL					

Barn yard grass (various dates)					

Photo (series) 10 Thin film degradation and crop development site 2 (N-S rows) Griffith

Griffith TRIAL 2012 Site 2: 4.10.12	DATE 1.11.12	DATE 1.11.12	DATE 12.3.13	DATE 12.3.13 (Film below ground)	DATE
Plastic 1					
Plastic 2					
CONTROL					

Other (various dates)					

Outcomes

5. 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 project has demonstrated that thin biodegradable film may have a place in the cotton production system; soil temperature is elevated and seedbed moisture is conserved, which results in earlier and uniform emergence compared with bare soil under the same conditions. A limitation to this point has been timely access to thin film to enable an early planting date and the inability of emerging cotton to penetrate the thin film. After discussion with one manufacturer agreement has been reached to slot the film over the plant line which should allow the crop to emerge. This concept has yet to be tested; field trials will be conducted in central Queensland during the 2013/2014 season. Further planting date experiments are planned for southern NSW and at ACRI using slotted film to determine whether the perceived benefit of using thin film is real and whether or not early planted cotton will survive subsequent cold shock or frost.

6. Please describe any:-
   a) Technical advances achieved (eg commercially significant developments, patents applied for or granted licenses, etc.);
   b) other information developed from research (eg discoveries in methodology, equipment design, etc.); and
   c) Required changes to the Intellectual Property register.

   Not applicable

Conclusion

7. Provide an assessment of the likely impact of the results and conclusions of the research project for the cotton industry. What are the take home messages?

   Thin biodegradable film can elevate soil temperature and conserve seedbed moisture resulting in early and uniform crop establishment compared with bare soil. Cotton cannot penetrate current available thin films, although one formulation breaks down about the same time as cotton emerges (10 to 20 days). However, if the film remains intact, emerged cotton seedlings desiccate due to high head-space temperature. The surface film degrades completely by harvest posing no contamination risk. The buried edges degrade once exposed after cultivation.

   Further work needs to be undertaken with newly available slotted film to determine whether the benefit of early planting can be realised.

Extension Opportunities

8. Detail a plan for the activities or other steps that may be taken:
   (a) to further develop or to exploit the project technology.
   (b) for the future presentation and dissemination of the project outcomes.
   (c) for future research.

Simulation studies are planned to refine potential planting windows. It is envisaged that thin film would be used as a strategy to reduce potential re-planting in cool regions and as such would not be used over extensive areas.
Results have been presented at the Australian Agronomy conference. A paper is planned for the forthcoming Cotton conference. CSD has made presentations to growers in southern NSW.
Further field experiments are planned to determine the benefit of using slotted film and to refine planting windows.

8. A. List the publications arising from the research project and/or a publication plan. (NB: Where possible, please provide a copy of any publication/s)

Michael Braunack and Jo Price 2012 The potential for thin biodegradable film in the Australian cotton industry, 16th Aust. Agron. Conf., 14-18 Oct. 2012, Armidale, NSW http://www.agronomy.org.au/proceedings/

B. Have you developed any online resources and what is the website address?

No

Part 4 – Final Report Executive Summary

Provide a one page Summary of your research that is not commercial in confidence, and that can be published on the World Wide Web. Explain the main outcomes of the research and provide contact details for more information. It is important that the Executive Summary highlights concisely the key outputs from the project and, when they are adopted, what this will mean to the cotton industry.

The project has demonstrated that thin biodegradable film may have a place in the cotton production system; soil temperature is elevated and seedbed moisture is conserved, which results in earlier and uniform emergence compared with bare soil under the same conditions. A limitation to this point has been timely access to thin film to enable an early planting date and the inability of emerging cotton to penetrate the thin film. A film with slots the over the plant line should allow the crop to emerge. This concept has yet to be tested; field trials will be conducted in central Queensland during the 2013/2014 season. Further planting date experiments are planned for southern NSW and at ACRI using slotted film to determine whether the perceived benefit of using thin film is real and whether or not early planted cotton will survive subsequent cold shock or frost.

The use of thin film should only target early planting to reduce the risk of re-planting and allow continued planting to proceed as planned. The use of thin film may reduce the risk and cost of re-planting due to an early planting. There is the opportunity to plant on rainfall, rather than water-up, if conditions are suitable thus saving irrigation water as the thin film conserves seedbed moisture. With uniform emergence occurring under the film, and as confidence is gained, this may allow a reduced planting rate for early planting; an economic saving to growers. The film may also reduce loss of fertiliser during irrigation thereby maximising the benefit of applied fertiliser. The fact that the film is biodegradable and has completely degraded by harvest poses no risk of contamination in the harvested lint.