Australian Government
Cotton Research and Development Corporation

FINAL REPORT 2017

For Public Release

Part 1 - Summary Details

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

CRDC Project Number: **CSP1701**

Project Title:	**Mitigating & managing soil compaction for sustainable cotton production**

Project Commencement Date: 1/07/2016 **Project Completion Date:** 31/08/2017

CRDC Research Program: 1 Farmers

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Date Submitted: **27.10.2017**

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.

Soil compaction is a hidden and continuing constraint to cotton productivity due to increasing size and weight of equipment and is estimated to be in the order of >$30M in lost revenue. Growers recognise compaction is an issue and address this by adopting pseudo-controlled traffic farming systems, however the incompatibility of equipment used by different crops restrict options for a fully matched CTF system. Identifying the extent of compaction is problematic: penetrometers measure soil strength which is dependent on soil moisture making interpretation difficult.

The project will engage with the cotton industry using discussion around soil pits in each cotton region to determine the extent of soil compaction as a constraint or cost to productivity with respect to water, nitrogen and energy use efficiency and subsequent yield and fibre quality. A recent survey of a limited number of growers suggested that 35 % of growers need to be able better identify soil compaction and have access to new strategies to "avoid" compaction, while the remaining 65 % would like novel strategies to ameliorate compaction and understand which strategies were more effective than others. These results indicate that the cotton industry appreciates that soil compaction is an issue and are looking for strategies to minimise the effect in the first instance and to determine which remediation practices are the most effective.

Soil compaction is seen as a negative in farming systems, perhaps we need to reassess the issue. Agricultural industries need to utilise soil compaction for benefit; as in a fully matched controlled traffic farming (CTF). Soil compaction is a constraint to productivity when it is allowed to occur in a random fashion, for example a non CTF system. This enables soil between traffic lanes to be managed optimally for water and nutrients and for crop growth. There is opportunity to manage or minimise the effect of soil compaction in cotton systems as growers tend to be land "rich", providing an opportunity to ameliorate the effect of a wet pick by increasing the time between cotton in any one area.

The project plans to determine how growers currently identify soil compaction and the extent of the problem and to identify current strategies for minimising compaction in the first instance and then determine what growers are implementing to ameliorate/mitigate the effect of compaction. A key component in this is, how do growers decide which strategy to adopt and what is the criteria of success or otherwise of the outcome? By minimising compaction in the first instance the necessity for amelioration is minimised, which will reduce the cost of production. This should translate into greater water and fertiliser use efficiency and less greenhouse gas emissions. The industry will be able to optimise resource use to maximise productivity per ML of limited water. A key component of the project will be understanding how soil constraints are prioritised within the farming and management system.

Objectives

2. List the project objectives and the extent to which these have been achieved, with reference to the Milestones and Performance indicators.

A workshop was held in Moree (14 July 2016) to discuss soil constraints and gain some insight as to current understanding of issues that the cotton industry is concerned about. A total of 32 participants attended including representation from CDRC, growers, consultants, CottonInfo members and researchers. There were many opinions expressed ranging from: the issue of soil compaction was serious to that it was not an issue. There is evidence that growers are experiencing compaction issues by having to irrigate more frequently and when deep ripping is used to loosen soil less irrigation is required: some growers are managing the crop on shallow profiles and compensate by increasing inputs to achieve high yields.

Currently there is a lack of concrete evidence that soil compaction is affecting productivity since some crops are achieving record yields. This again suggests that growers are compensating by increasing inputs which may be a greater impost than managing or mitigating the problem. Evidence was provided from a survey of water extraction profiles which indicated that roots were not extracting water below 60 cm which compounds the issue of compaction at depth, since research has shown the round module picker can result in compaction to depths of 70-80 cm restricting root development. Much interest was expressed in the potential gross margin increase (not yield) through conversion to CTF, with desire to see more case studies around this.

Growers also expressed the need for simple tools to identify the level and extent of compaction across a field.

It was suggested that the issue of soil compaction not be considered in isolation but in a systems context as picking traffic is not the sole source of compaction: it starts with fertiliser application and planting operations.
Following on from this meeting CottonInfo representatives from each cotton region were contacted to determine interest in identifying “champions” who were interested/concerned about soil degradation and may be interested in hosting a soil pit/discussion session. Positive responses were received from all those contacted and discussion on activity, time and locations are currently underway.
A follow-up meeting was held at CRDC on 18 October with a phone hook-up between project leaders, CRDC and CottonInfo to plan direction and timing of industry engagement for the remainder of the project.
Presentation, discussion and attitudinal observation at three industry events attended by cotton growers: Society of Precision Agriculture Australia, Gunnedah symposium – 30 min presentation (~20 growers), Tulloona Conservation Farming Group/ Conservation Farmers Inc. field day, Moree – 1.5 hour soil pit discussion on a CTF site and 45 min presentation (~50 growers), Jimbour Cotton Growers Group – 45 min CTF presentation and 60 min open discussion (~20 growers).
Attendance at the Gwydir Valley Irrigation field day at Auscott, Moree on 8 February 2017 generated much discussion around the true benefit of controlled traffic, presentation and discussion (~ 30 min) continued at the following site at Red Mill with growers (~ 100 participants).
Attendance at the Southern Valley’s CGA field day 31 March 2017 where a soil pit was used to illustrate the effect of field traffic and possible strategies to minimise the impact resulted in 60 min discussion (~ 120 growers).
Attendance at the Cotton Collective, Griffith 26-27 July 2017 specifically to discuss with growers and consultants issues associated with in-field traffic and mitigation strategies currently used.
The project has identified that soil compaction is an issue for the cotton industry although opinion varies as to extent and cost.
Growers are tacitly recognising the problem by modifying track widths of pickers to minimise the area trafficked.
Growers use rotation/break crops to ameliorate the effect of soil compaction, with only anecdotal evidence that some improvement occurs.
There is no long-term study to indicate if any one rotation is better than any other rotation.

Methods

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

This work will undertake industry workshops throughout the cotton industry, targeting major production regions via regional centres. The majority of the proposed work is extension based. The output will be a report of the major findings that will inform subsequent investment in soil compaction by CRDC.

The structure of events will be an open forum event that is designed to facilitate an interactive approach to extension. Coupled with this will be focussed on farm visits with preselected regional champions (to be identified via CottonInfo).

Industry engagement through a targeted workshop initially in conjunction with soil pit days, and contact with key growers facilitated by the CottonInfo team was planned to assess the questions posed: Is soil compaction perceived to be an issue for the cotton industry? And what strategies do growers use in identifying & managing soil compaction? Attendance at local grower field days, meetings and industry conference also presented opportunities to engage with growers and industry leaders.

The main lesson learned is that all parties involved with the project need to be actively engaged and committed for the best outcome to be achieved, which requires time to be allocated commensurate with the commitment.

Results

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

What strategies do growers use to identify and manage soil compaction?

Several soil pits were conducted at the request of growers and consultants to show growers the effect of round module picker traffic in the Gwydir valley in 2013, 2014, and 2015 and in southern NSW in 2015 and 2017, in Central Qld in 2016 (with CottonInfo), and at Dalby, Qld in 2017 (with CottonInfo).

Questions focussed around the main concern of identifying the extent of compaction across the field and what do we do about it, through to we know it occurs but cannot do anything about it and we are not convinced that it is a problem. In reality there should be no problem in identifying the extent of compaction across a field: it coincides with the wheel tracks of the pickers affecting four furrows, severely impacting two plant lines (both sides) and moderately impacting four plant lines (one side) in every six harvested rows.
The use of rotation or break crops to dry the soil profile and induce cracking is perceived to be the best strategy to remediate soil structural degradation, however such a crop usually only experiences one wet/dry cycle while inducing large lateral cracks does little to remediate soil structure at depth. Previous research indicates Vertosol soils need to experience 9 – 10 wet/dry cycles are necessary before structure begins to recover. A range of rotation/break crops are grown by growers including wheat, barley, triticale and chickpeas, field peas, mung beans, pidgeon pea, sunflower, safflower and maize. The question most often asked is which crop is best in drying the profile and regenerate structure, and to what depth does improvement occur?
Growers also invest in deep ripping or blade ploughing to alleviate soil compaction at depth, the danger in this strategy is, if soil moisture at the depth of ripping or blading is at or above the soil plastic limit a smeared compacted layer may be created at the depth of the operation resulting in a constraint deeper in the profile than previously. Research has shown the effect of deep ripping is relatively short lived.
At times compaction is only acknowledged/recognised after a wet pick and this is the only time something needs to be done. When growing a rotation crop a wave pattern is often observed and is associated with the position of picker traffic, a surrogate way of recognition of compaction issues. At times growers recognise that actual yield is lower than expectation and ask why: seasonal conditions or some other reason?
There seems to be a lack of practical information available to growers that enable them to manage the perceived problem and to convince the sceptics that compaction is a problem.

Initial contact with CottonInfo REO's was positive, however follow-up activity has been limited due to agreement on timing and priority of activities, cotton picking and other commitments.

Is soil compaction perceived to be an issue for the cotton industry?

The response is varied from acknowledgment that compaction is a real issue, that it is acknowledged but we need to pick the crop to avoid quality penalties through to compaction is not an issue. The extent of these different attitudes needs to be clarified. When growers are engaged in a one-to-one discussion compaction is recognised as an issue for the industry.

A successful soil pit has been conducted on the Darling Downs with two interested growers due to yield expectation being down on the previous two seasons and wanting to explore possible causes.

The growers at the soil pit's on the Darling Downs appreciated that extensive compaction across the field was potentially a contributing factor to lower yields experienced in the current growing season. In combination with unseasonal factors, such as cold conditions, high humidity and prolonged high temperature poor soil conditions will exaggerate these factors if management does not overcome it. The comment made was that they did not appreciate the problem and extent of soil compaction as it is invisible. There is a need to improve soil quality of cotton fields to increase soil resilience in buffering the effect of atypical seasonal conditions.

From presentation at three industry events: SPAA meeting at Gunnedah, CFI Tulloona and CGG Jimbour representing an approximate total of 90 growers there was clear acknowledgement that compaction had an effect, even for those suggesting it was not an issue for their system. The point of contention appeared to be how deep does compaction occur and how quickly can it be remediated? Once the depth effect and management approaches were discussed, there was clear understanding and agreement that compaction was an issue for the industry and the discussion focus turned to economics and system.

Identification of research needs

From the three field days presented at there is anecdotal requirement for a long-term demonstration site/s in the regions to capture the effect of compaction and possible remediation strategies over time. There was direct request for further information regarding the economic potential benefit of moving towards CTF, which requires monitoring sites to be assessed over time, and importantly requires a reference point (i.e. non-CTF side-by-side). The second part of this discussion then becomes system integration: How can CTF be incorporated given a minimum requirement to move to a 3 m internal track? Could a 4 m internal track be used? Which row spacing's are appropriate in terms of physiology, but with direct link to change in compaction profile? Can we simply manage inputs around the issue

and avoid CTF altogether? It is anticipated that once a decision to make a change will be that the agronomic practices to manage the crop will follow.
Currently several growers/contractors have modified round module pickers to run on a 3 m track width, with others considering moving to a 4 m track width to better integrate with the cereal system used. One advantage of a 3 m system is machinery can be moved between fields without escorts which would be a requirement if using a 4 m system. The fact that there is a move to 3 or 4 m systems suggests that compaction is being recognised as a problem and this is one possible solution to minimise the area trafficked and optimise the area available for crop growth.
Currently growers are making changes with little or no knowledge of potential benefit or whether the change was necessary in the first place, there is no knowledge about the potential yield losses incurred due to soil compaction and picker traffic specifically. The difficulty arises from the fact that crop yields have been increasing, hence the perception that compaction is not an issue. Also, there is little tangible evidence that rotation crops are remediating soil compaction, largely due to the fact that the common rotation is one cotton crop followed by a rotation crop and back to cotton. Overseas research has indicated that it can take between 10 to 15 years after compaction with a 15 tonne axle load for a crop response to be observed, round module pickers have a 32 tonne load on the front axle.

There is a need to quantify the cost of in-field picker traffic: research should be initiated to determine whether plants either side of picker tracks stress earlier and maintain stress for longer periods than rows not influenced by picker traffic. It is possible to measure this with canopy temperature sensors and a thermal imaging camera, thereby enabling prediction of yield loss. Yield of individual rows can be measured using the yield monitor on the picker. Results can be used to provide the economic framework to inform the need for strategies for growers to potentially manage impacted areas in the next cotton crop, thereby maximising resource use efficiency; be it nutrients or water. There is a need to build some resilience into the system by managing soil compaction either by minimising the issue in the first instance or developing mitigation strategies. If soil structural damage is minimised, conditions conducive to root growth exploiting the whole soil profile enables the crop to better utilise water and applied fertiliser and soil biology can be maintained, which can result in reducing the effect of soil borne disease and insect infestations. This provides resilience to the system for the future especially under changing climatic conditions of less water and higher temperatures.
We need to be more proactive rather than reactive in developing strategies to minimise the deep soil profile compaction before it becomes a greater problem.

The most recent CCA survey indicated that 60 % of the cotton industry is impacted by soil compaction and of this 29,000 ha was estimated to have a 1 bale/ha, and 11,300 ha was estimated to have a 1-2 bale/ha loss due to compaction (Crop Consultants Australia 2016, Qualitative report on the 2014-15 cotton season: a survey of consultants. CRDC, Narrabri, 37p.).
Yes, soil compaction is an issue for the cotton industry, however it seems not publicly acknowledged. Growers generally admit that compaction is an issue with varied consequences: it is an issue, however there is not a lot we can do about the problem through to it is an issue and I do not know how to deal with the problem.

How do growers recognise compaction?

Root growth, water infiltration, ponding, waves in crop, after a wet pick

At times compaction is only acknowledged/recognised after a wet pick and this is the only time something needs to be done. When growing a rotation crop a wave pattern is often observed and is associated with the position of picker traffic, a surrogate way of recognition of compaction issues. At times growers recognise that actual yield is lower than expectation and ask why: seasonal conditions or some other reason? Growers and/or consultants request that a soil pit be conducted to assess poor performance in the previous crop.

What strategies do growers use in managing soil compaction?
At this point in time there is no long-term rotation that can be identified to either reduce the impact of in-field traffic by pickers by mitigating compacted soil at depth, usually the rotation grown only experiences one drying/wetting cycle which is not sufficient for soil structural regeneration.
Further studies need to examine the effect of different rotation/break crops over the longer term in a cotton system, perhaps in conjunction with tillage for pupae control. Strategies to increase wetting and drying of the profile need to be explored for structural regeneration and rooting depth.
Deep tillage & ripping, CT, minimise traffic weight, min till, crop rotation, dry the profile, manage last irrigation, lime/gypsum, manure application, aerial spraying (Root growth, water infiltration, waves in crop, wet pick (Roth Rural 2013, Cotton growing practices 2013: findings of CRDC's survey of cotton growers. CRDC, Narrabri, 72p.).

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 confirmed that soil compaction is an issue for the cotton industry, although it is not discussed openly. The fact that some growers have converted equipment to 3 m and are considering 4m is an admission that soil compaction is of concern. The problem remains as to how best integrate these changes into the current system when rotation crops are to be included, a decision needs to be made as to whether the remediation of soil compaction is of greater benefit than short term gains of wet picks and not committing water to a rotation crop to maximise wetting/drying cycles.
It is doubted whether growers require the means of recognising or defining the extent of soil compaction in any particular field: it corresponds to the paths that picker's traverse and the area that the pickers and traffic to collect the in-field modules, these are the zones that will need remediation.

6. Please describe any:-

a) technical advances achieved (eg commercially significant developments, patents applied for or granted licenses, etc.);
None

b) other information developed from research (eg discoveries in methodology, equipment design, etc.);
None

c) required changes to the Intellectual Property register.
None

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?

If follow-up research is undertaken to identify the cost of in-field traffic and the benefit of modifying equipment established, the potential benefit is an extra 2 bales/ha as indicated from the CCA report.
Manage soil compaction for benefit to the system and optimise soil conditions between compacted zones for crop growth.

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.
Spotlight articles, Australian Cotton Grower, Journal publications

(c) for future research.
Demonstrate benefit of CTF
Develop effective crop rotations
Determine cost of compaction
Calibrate a traffic model for the cotton industry

9. 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)

Article in Spotlight (Winter 2017)

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

No

Part 4 – Final Report Executive Summary

The project engaged with the cotton industry through the attendance at grower organisation field days and meetings to assess industry attitude to soil compaction by round module pickers. Initial reaction from attendees varied from: yes compaction is an issue but we do not know how to manage the problem to what are the best crop rotations to mitigate soil compaction. To demonstrate the impact of the pickers several soil pit days were undertaken which often convinced attendees that the problem was real. To some extent the industry is further recognising soil compaction by modifying equipment wheel tracks to 3 and in some cases considering 4 m wheel tracks to better fit with cereal crops grown in rotation with

cotton. Currently there is no long-term information on which crop rotation sequence or tillage operations actually improves degraded soils or as to how long alternative crops should be grown in ex-cotton fields. There is an expectation that if a change is made to the system there should be a response, unfortunately it takes time for the response to occur.

Work needs to establish the cost of in-field traffic in yield loss and resource use as this may demonstrate to the industry that the cost of compaction is both real in the short- and long-term. Further work needs to be undertaken to establish the benefits of modifying equipment vs doing nothing. The effect of rotations/break crops and the length of the break and the management thereof should be assessed for benefits in structural regeneration and subsequent cotton performance.