Final Report

1. Project Information

GRDC Project No: CCC00004

Line of Business: Practices

Program: Agronomy, Soils and Environment

Project title

High Yielding Irrigated Grains in Cotton Farming Systems

Commencement date	Completion date	Number of years
01/05/2007	01/05/2012	5.00

2. Contact Information

Project Supervisor Contact

Title	Initials	First name	Family name (Surname)
Mr	J	John	Sykes

Position: Project Supervisor

Name of organisation: Cotton Catchment Communities CRC

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Administration Contact

Title	Initials	First name	Family name (Surname)
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Position: Project Management Officer

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3. Budget Summary

Financial Year	2006 | 2007 $	2007 | 2008 $	2008 | 2009 $	2009 | 2010 $	2010 | 2011 $	2011 | 2012 $	Total $
Total GRDC $ Agreed (excl GST)	111,602	229,126	225,432	219,981	219,697	220,909	1,226,747

4. Project Summary

The High Yielding Irrigated Grains in Cotton Farming Systems (HYIGCFS) project combined new research information with that from a "sister" project, Achievable Yields (AY). 14 key project recommendations were developed. The opportunity was then taken to document research and commercial experience (since 2007) and produce the first set of best practice guidelines for irrigated wheat grown in cotton farming systems-see Appendix 1.

The HYIGCFS project focused on low soil-N (soil nitrogen) paddocks sown to wheat straight after cotton; while the AY project focused more on high soil-N/long fallow paddocks (similar to that witnessed in 2008 when irrigated wheat paddocks lodged badly).

5. Outcome Benefits

Before 2007, very little research had been done to develop management guidelines for irrigated wheat in the northern region, and information had been traditionally sourced from southern NSW irrigated counterparts.
In 2008, NSW was in the midst of a serious drought. A combination of low cotton prices and low water allocations along with high wheat prices ultimately saw cotton growers swapping to high-yielding irrigated wheat on their fallowed paddocks.
During the 2008 season many growers encountered a very wet establishment period, and many crops were sown after a long fallow. Once these crops were watered-up in a high soil nitrogen (high-N) environment, most varieties performed poorly. A large percentage of crops produced massive biomass that was not transferred into grain yield (as a result of lodging) and large economic losses were suffered.
Confidence to manage a high yield potential wheat crop was significantly reduced.
Researchers then used a combination of on-farm monitoring, small plot trials, and computer modeling with the Agricultural Production Systems Simulator (APSIM) model to maximise yields. Modeling indicated that yields of 8t/ha are regularly achievable with a quick-maturing variety (such as Kennedy) across most of the northern region but this " does depend on weather conditions during a given year".
Since 2007, some commercial crops have recorded high yields (8t/ha plus at Walgett, Springsure and Brookstead) to demonstrate lodging can be effectively managed.
Additionally, trial plots of commercial varieties have yielded greater than 9t/ha at ACRI,Narrabri in 2011.
The major outcome of this project is that it is now recognised there are different but critical management decisions in growing high yielding irrigated wheat in high or low soil nitrogen paddocks. The key is to know the paddocks starting soil-N levels, and to then adjust water and nitrogen availability during the growing season.
Best practice guidelines for irrigated wheat in the northern region provide new information on nitrogen application, establishment, irrigation, controlling lodging via canopy management and disease management. These guidelines provide an opportunity for cotton growers to manage lodging and maximise profitability for high yielding crops.
Alternatively growers can choose to reduce yield target and maximise land area or water availability.

6. Pesticide and Herbicide Research

Did this project conduct research on pesticide and herbicide products?

No ☑

Yes ☐ List the active ingredients, rate and timing

7. Outputs

Reproduce any outputs not previously reported against

Output 1

Planned delivery date: 01/05/2012

Achieved: Yes

Description

Coordinate, publish and deliver "Best Practices Guidelines for Irrigated Wheat in the Northern Region". Carry out case studies, grower workshops and detailed research trials to develop recommended practices. Validate Best Practice Guidelines with agronomists/consultants before release to ensure they are published in a format easily accessed and then regularly used as the leading management resource.

Achievement prior to this report

Approx. 40 case studies, 8 workshops and on-farm trials were carried between 2008 and 2011.
Detailed research trials were carried out in 2010 at ACRI Narrabri on varieties, row spacing, N application and irrigation frequency.

Achievement for this reporting period

Detailed research trials were undertaken at ACRI Narrabri and LPFS Breeza on establishment techniques, N application, varieties and irrigation timing. Three grower workshops were undertaken.
Best practice guidelines were documented from commercial and research information and made available to 12 consultants for review.
See Appendix

Achievement of commercialisation details

N/A

Non-achievement details

NIL

Output 2

Planned delivery date: 01/05/2012

Achieved: Yes

Description

Publication of WATERpak supplement, "Guidelines for Irrigation Scheduling in Winter Cereals" that focuses on maximising $/ML returns. Carry out on-farm field demonstrations showcasing recommended irrigation practices in areas from the Macquarie Valley to Emerald.

Achievement prior to this report

On-farm studies were undertaken in 2008/2009 and detailed research in 2010 at ACRI Narrabri.

Achievement for this reporting period

Detailed information on irrigation guidelines for wheat have been written up by project team members and will be used as a supplement for the release of WaterPak. See Appendix 2

Achievement of commercialisation details

N/A

Non-achievement details

Due to the difficulty of running on-farm irrigation trials all research was conducted at selected sites at Kingsthorpe, ACRI Narrabri (2010 and 2011) and LPFS Breeza, Liverpool Plains (2011).

Final Report

Output 3	Planned delivery date	Achieved
	01/05/2012	Yes

Description

Web based-easy to use system to assist irrigation growers undertake whole farm economic analysis of water budgeting across a number of alternative crop enterprises and sources of irrigation water.

Achievement prior to this report

A web-based system was developed by Daniel Rodriquez (DAFF Queensland) and evaluated by growers/consultants at Wee Waa. www.apsim.info/irrigationoptimiser or google QPIF Irrigation Optimiser.

Achievement for this reporting period

Project staff reviewed Irrigation Optimiser and agreed it provided a support tool suitable for use by growers/consultants. A manual water budgeting example was developed by Rod Jackson (NSW DPI) for use in best practice guidelines. Irrigation frequency data from ACRI transferred to CSIRO to upgrade APSIM model to review various water deficit scenarios.

Achievement of commercialisation details

N/A

Non-achievement details

Further interaction with irrigation farmers would benefit the adoption and use of the Irrigation Optimiser web based tool.

8. Milestones

Milestone number: 1	Planned achievement date	Achieved
	31/05/2007	Yes

Description

Appoint a Research Agronomist.

Achievement prior to this report

Research agronomist appointed in 2007. Maternity leave taken from June 09 to March 2010-- then continued as part time employment (3 days/week).
John Sykes contracted as project supervisor (2 days/week) from March 2011.

Achievement for this report

Research Agronomist finalised appointment on May 1 2012.

Milestone number: 2	Planned achievement date	Achieved
	01/05/2012	Yes

Description

Design and undertake detailed field trials to compare methods of seed bed wetting and sowing configurations. Establishment trials will be conducted at Research Centres to compare sowing into moisture and irrigating up scenarios. They will be supported by on-farm case studies (20 minimum) to review seed bed wetting treatments and establishment success. Design and undertaking of field trials will be carried out in consultation with scientific and biometric support to improve data quality.
Criterion: results summarised and presented as a segment of Best Practice Guidelines.

Achievement prior to this report

Detailed on-farm trials undertaken in 2008 and 2009. Research undertaken at Kingsthorpe, Goondiwindi and Narrabri in 2009 and 2010. Research focused on nutrition, sowing method, row spacing, variety response and irrigation frequency.

Achievement for this report

Detailed research undertaken at ACRI Narrabri and LPFS Breeza (Liverpool Plains) in 2011.
Research trials focused on establishment methods, row spacing, varietal response and irrigation frequency. Data was exported to APSIM model to review various irrigation scenarios. See Appendices 1,7,8 and 9.

Milestone number: 3	Planned achievement date	Achieved
	31/05/2008	Yes

Description

Conduct literature review and detailed trials on nutrition strategies to identify: 1) methods of applying required nutrients relative to field operations for crop establishment 2) nutrient requirements relative to crop rotations 3) methods and timings for determining nutrient requirements 4) risk and reward profile of split application and foliar strategies compared to pre-plant applications.
Criterion: Incorporate recommendations in Best Practice Guidelines for Irrigated Wheat to be delivered to industry in May 2012.

Achievement prior to this report

Literature review completed in 2010-see Appendix 3. All trials above have been completed (some as Ph.D. studies-B.Griffiths) and results used extensively in 2 sections of Best Practice Guidelines that provide key recommendation on nitrogen and phosphorus management in cotton farming systems--see Appendix 1-Section 2.

Achievement for this report

N/A

Milestone number: 4	Planned achievement date	Achieved
	01/05/2012	Yes

Description

Coordinate results of milestone 3 with canopy management trials to reduce the risk of lodging.
Criterion: detailed trials undertaken to review the performance of leading varieties and use of plant growth regulators.
Results incorporated into Best Practice Guidelines for Irrigated Wheat as above.

Achievement prior to this report

On-farm demonstrations were conducted in 2008 and 2009. Ph.D. studies (B.Griffiths) were conducted at ACRI in 2010 to develop canopy management recommendations involving nitrogen application, row spacing, plant growth regulators and sowing time. Leading varieties (11) were reviewed across irrigation frequency trials.These complimented research undertaken by in another project--Achievable Yields (Allan Peake CSIRO)

Achievement for this report

Replicate research trials as above were undertaken in 2011 at ACRI Narrabri and LPFS Breeza but varietal performance reduced to 4 (2 durum and 2 bread wheat). See Appendix 1-Section 2.

Milestone number: 5	Planned achievement date	Achieved
	01/05/2012	Yes

Description

Use results of Milestones 2, 3, and 4 to develop an interim version of "Best Practice Guidelines for Irrigated Winter Wheat in the Northern Region" by 31/07/2011 and final publication of the document by 1/05/2012.
Criterion: Guidelines validated with agronomists/consultants (10-12) before release to ensure they are published in a format easily accessed and then regularly used as a leading management resource.

Achievement prior to this report

Draft guidelines were developed in late 2011 and underwent approximately 20 modifications.
Draft guidelines forwarded to 10 agronomists/consultants for review--limited but positive feedback obtained.

Achievement for this report

Irrigated Wheat --Best Practice Guidelines in Cotton Farming Systems undertook final editing in May 2012 and was published in late May 2012. See Appendix 1

Milestone number: 6	Planned achievement date	Achieved
	30/07/2007	Yes

Description

Design, build and install 12 lysimeters at Kingsthorpe.

Achievement prior to this report

12 weighing lysimeters were designed, constructed and installed at Kingsthorpe Research Station in November 2008. They were used to collect cotton and wheat data from deficit irrigation trials in 2008 and 2009 seasons.

Achievement for this report

N/A

Milestone number: 7	Planned achievement date	Achieved
	30/11/2008	Yes

Description

Undertake deficit irrigation study using the lysimeters at Kingsthorpe to determine the response of a wheat crop to deficit and full irrigation regimes. This Milestone will reoccur in 2009.

Achievement prior to this report

2008-increased irrigation frequency increased crop LAI, plant height, yield, lodging and decreased grain protein. Maximum gross margin at 60% depletion of ASW (compared to 50%,70% and 85%)

Achievement for this report

Irrigation frequency data provided to CSIRO (Allan Peake). Computer modeling with the APSIM Farming Systems model successfully undertaken and results utilised in Best Practice Guidelines-see Appendix 1.

Milestone number: 8	Planned achievement date	Achieved
	31/05/2009	Yes

Description

Prepare and present one conference paper arising from the lysimeters study.

Achievement prior to this report

Two papers based on research at the Lysimetry facility were presented at the Aust Irrigation Conference (June 2010) and one paper presented at the 15th Aust Agronomy Conference (November 2010). See Appendix 1 -Further Reading

Achievement for this report

N/A

Milestone number: 9	Planned achievement date	Achieved
	31/03/2010	Yes

Description

Develop case studies of the irrigation and establishment practices of growers who are committed to irrigating winter cereals in 'hot' and 'cool' areas of cotton regions.

Achievement prior to this report

Case studies were setup to identify the practices used to grow irrigated wheat crops across irrigation wheat farms in northern NSW. Economic analyses (including nutrition, plant counts, paddock operations) completed in 2010. See Appendix 5 and 9.

Achievement for this report

N/A

Milestone number: 10	Planned achievement date	Achieved
	31/05/2008	

Description

Undertake detailed trials to review spring irrigation requirements of wheat in the northern region (short grain fill period)
Criterion: Irrigation data sets (2 years) comparing nil, limited and full irrigation scheduling of wheat varieties in northern NSW.

Achievement prior to this report

Protocols submitted. Irrigation scheduling demonstrations undertaken in the Namoi Valley in 2009 but replaced with extensive set of trials at ACRI in 2010. Major trial- irrigation regimes x 11 varieties.

Achievement for this report

Extensive set of trials at ACRI Narrabri and Breeza successfully undertaken for a second year 2011. Major trial--establishment method x 4 varieties x irrigation regimes. See Appendix 9

Milestone number: 11	Planned achievement date	Achieved
	31/08/2011	

Description

Prepare 2 scientific papers arising from the lysimeter study and submit for publication (end date 31/08/2011).
Criterion: 2 scientific papers submitted for publication.

Achievement prior to this report

Two papers were prepared on:
*evaluation of alternative irrigation strategies for wheat (in response to limited water situations) - an expansion of the paper presented at the Australian Agronomy Conference 2010
*likely climate change impacts on irrigated wheat production

Achievement for this report

Irrigation frequency data from research trials at ACRI Narrabri have been provided and used to improve procedures currently used in APSIM to model ET and yield under full and deficit irrigation. See Appendix 1-Further Reading.

Milestone number: 12	Planned achievement date	Achieved
	01/05/2012	

Description

Prepare best practice guide for irrigated grains in the northern region.
A WATERpak supplement "Guidelines for Irrigation Scheduling in Winter Cereals" will be prepared for inclusion in "Best Practice Guidelines for Irrigated Wheat in Northern NSW" in print and web form.
Criterion: Guidelines ready for publication by end of project.

Achievement prior to this report

A draft best practice guide for irrigated wheat in the northern region was initially developed by Rod Jackson (NSW DPI). This was modified for use in Best Practice Guidelines --section 3 --see Appendix 1

Achievement for this report

Irrigated wheat guidelines have now been reviewed by Jose Payero/Graham Harris (DAFF Qld) and further developed for the release of WaterPak. Wheat irrigation guidelines are being used as the model for other crops in the release of the new WaterPak. See Appendix 2

Milestone number: 13	Planned achievement date	Achieved
	30/11/2007	Yes

Description

Report on interviews with decision makers and scoping analysis on needs and features of the whole farm water allocation decision support tool.

Achievement prior to this report

Web based system was developed by Daniel Rodriquez (DAFF Queensland) and evaluated by growers/consultants at Wee Waa. www.apsim.info/irrigationoptimiser or google QPIF Irrigation Optimiser.

Achievement for this report

DAFF Queensland have relayed all commitments have been met in the development of the Irrigation Optimiser. It is functional and available on the web. It will be promoted on a new web at www.moreprofitperdrop.com.au in 2012.

Milestone number: 14	Planned achievement date	Achieved
	30/11/2008	Yes

Description

Decision support tool evaluated as per collaborating farmers and fully functional on CCC CRC web site.
Improved confidence on existing modeling tools to simulate water use by wheat and cotton.
Criterion: preliminary version of agronomic and economic decision support tool (with application in all cotton regions) available for further validation / pilot adoption program. Report on APSIM's capacity to simulate wheat and cotton production and water use under irrigated and rain fed conditions.

Achievement prior to this report

Irrigation Optimiser evaluated at 2 workshops on release. Further promotion is recommended. DAFF Queensland are releasing a new web site at www.moreprofitperdrop.com.au in 2012.

Achievement for this report

The APSIM simulation model has been developed and used to generate approximate guidelines for growers wishing to maximise their crop water use efficiency (CWUE). Irrigation scenarios have also been modeled for limited water availability through to complete irrigation requirements for maximum yield--see Appendix 1 and data submission example Appendix 6

Milestone number: 15	Planned achievement date	Achieved
	30/11/2009	Yes

Description

Improved capacity to increase profits by optimising the allocation of irrigation water and land across a number of irrigated and rained cropping enterprises.
Criterion: Decision support tool and supporting documentation available and used by at least 10 growers, and report on case studies and a number of workshops on the use of the new decision support tool delivered on due time.

Achievement prior to this report

Irrigation Optimiser finalised. Data generated for APSIM simulation model.

Achievement for this report

Cotton growers did not plant wheat in the 2010 and 2011 seasons because land and water availability was maximised for cotton production (case studies not possible). 3 workshops were conducted in 2011 with varying participation.

9. Delivery Activity— Decision Support Tools

What were the proposed target audiences and/or organisations for the activities/outputs? (e.g. Grain growers, agribusiness, researchers, breeders)

Irrigated Wheat-Best Practice Guidelines--growers and consultants

Was this activity/output delivered as part of the project?

No ☐
Yes ☑

Date of delivery (dd/mm/yyyy)

01/10/2011

Was there recurring years for this activity/output?

No ☐
Yes ☑ Month and year of activities/outputs

1/5/2012

Did this activity/output include third parties?

No ☑
Yes ☐ Name of principal contractor

Was this activity/output funded within the project budget?

No ☐ Details of external funding

Yes ☑ **Include in budget and operating notes.**

Was this activity/output national/regional/local?

National ☐
Regional ☑ Specify region if possible

northern

Local ☐ Specify locality if possible

Final summary of the outcome for this activity/output

Data from case studies and on-farm research in 2008 and 2009 was used along with extensive research findings from 2 projects. Draft information was made available in 2011. Publication finalised by June 1 2012.

Delivery Activity— Support programs

What were the proposed target audiences and/or organisations for the activities/outputs? (e.g. Grain growers, agribusiness, researchers, breeders)

WaterPak--the version for irrigated wheat is being developed by DAFF Qld and will be trialed on-farm in 2012.

Was this activity/output delivered as part of the project?

No ☐
Yes ☑

Date of delivery (dd/mm/yyyy)

31/05/2012

Was there recurring years for this activity/output?

No ☑
Yes ☐ Month and year of activities/outputs

1/5/2012

Did this activity/output include third parties?

No ☑
Yes ☐ Name of principal contractor

Was this activity/output funded within the project budget?

No ☐ Details of external funding

Yes ☑ **Include in budget and operating notes.**

Was this activity/output national/regional/local?

National ☐
Regional ☑ Specify region if possible

northern

Local ☐ Specify locality if possible

Final summary of the outcome for this activity/output

WaterPak is a Cotton Industry initiative which is being progressed with input from DAFF Qld and irrigation guidelines for wheat was finalised in May 2012.

Delivery Activity— Decision Support Tools

What were the proposed target audiences and/or organisations for the activities/outputs? (e.g. Grain growers, agribusiness, researchers, breeders)

Whole Farm Economic Analysis--cotton growers and consultants

Was this activity/output delivered as part of the project?

No ☐
Yes ☑

Date of delivery (dd/mm/yyyy)

01/05/2009

Was there recurring years for this activity/output?

No ☑
Yes ☐ Month and year of activities/outputs

Did this activity/output include third parties?

No ☑
Yes ☐ Name of principal contractor

Was this activity/output funded within the project budget?

No ☐ Details of external funding

Yes ☑ **Include in budget and operating notes.**

Was this activity/output national/regional/local?

National ☐
Regional ☑ Specify region if possible: northern

Local ☐ Specify locality if possible

Final summary of the outcome for this activity/output

Web based system was developed by Daniel Rodriquez (DAFF Queensland) and evaluated by growers/consultants at Wee Waa. See the software at www.apsim.info/irrigationoptimiser or google QPIF Irrigation Optimiser.

Delivery Activity—

What were the proposed target audiences and/or organisations for the activities/outputs? (e.g. Grain growers, agribusiness, researchers, breeders)

N/A

Was this activity/output delivered as part of the project?

No ☐
Yes ☐

Date of delivery (dd/mm/yyyy)

Was there recurring years for this activity/output?

No ☐
Yes ☐ Month and year of activities/outputs

Did this activity/output include third parties?

No ☐
Yes ☐ Name of principal contractor

Was this activity/output funded within the project budget?

No ☐ Details of external funding

Yes ☐

Was this activity/output national/regional/local?

National ☐
Regional ☐ Specify region if possible

Local ☐ Specify locality if possible

Final summary of the outcome for this activity/output

Additional Extension Activities/Referred Publications (in bibliographical format)

These will be finalised in the next 12-18 months by Brendan Griffiths after Ph.D. studies have been finalised.
See CRC report by Brendan Griffiths.

Delivery/Path to Market

Project team members have produced 10 single story extension articles to promote project findings.
These will be finalised by the project supervisor and utilised in June to promote the release of the publication "Irrigated Wheat--Best Practice Guidelines in Cotton Farming Systems"

10. Environment/Economic/Social Analysis

Outline the benefits/risks associated with this proposed investment.

Benefits

Include an estimate of the benefit and the scale to which the impact will apply (i.e. ha, tonnes).
Also include likelihood of benefit and proposed extent of the adoption by industry in the project timeframesand beyond.

Risks

Include likelihood of risk and management options.

Environmental Benefits

A cropping system in which there is a combination of winter and summer cropping will reduce overhead costs, spread risk, increase the farm's overall water use efficiency, reduce the likelihood of herbicide resistant weeds, increase the efficiency of storing soil moisture, assist in maintaining soil quality and ultimately, increase profitability.

Environmental Risks

While cotton is always likely to be more profitable on a $/ha basis, given the reductions in water licences, a cereal rotation using half the irrigation input of cotton with competitive $/ML profitability to cotton, may only encourage but not progress the expansion of the cereal area while allowing stable areas of cotton production.

Economic Benefits

If cotton growers adopt an equally professional approach to the agronomic management of irrigated wheat than $return/megalitre can be improved. However even if wheat is not irrigated or sparingly irrigated yield improvements can be made by adopting recommendations that have been developed for the northern region to reduce lodging risk.

Economic Risks

While yields exceeding 8 t/ha do occur, the current production system is currently viewed as high risk due to inconsistent yields caused by lodging.

Social Benefits

Confidence can be provided to growers/agronomists/consultants with the publication of irrigated wheat -best practice guidelines. If it is readily used as a resource in the northern region the key project findings will become the basis for management of irrigated wheat. In this way management changes will be adopted as there is more confidence in utilising local research findings.

Social Risks

A farming community too dependent on cotton for farm income and without improved skills to grow irrigated winter grain crops.

11. Overview of Project Achievements

The following are key project results that have been identified between the period 2007 to 2011.

1. Soil-N Level
Key point: it is essential to conduct a nitrogen soil test in April/May before sowing
*long fallow paddocks (high soil-N) require careful management of canopy growth from establishment to avoid lodging
*paddocks sown straight after cotton (low soil-N) are ideal to target maximum yield and manage early season canopy

2. Row Spacing
Key point: 30 cm row spacing is ideal (6 rows on a 1.8 metre bed)
* 30cm row spacing (6 rows on a 1.8m bed) is ideal for reduced or maximum yield targets.
* 15cm or 45cm row spacing (4 or 12 rows on a 1.8m bed) have, in small plot trials, yielded significantly less than 30cm spacing at high yield levels.

3. Plant Population
Key point: aim for a plant population of 100-150 plants per square metre (+see below)
*Plant populations above 150 plants per square metre of bed are not essential for achieving high yields in the northern region.
*Low plant populations of 50-100 plants per square metre of bed can achieve high yield levels.

4. Seedbed Preparation
Key point: preparation of seedbed has a significant impact on seedling emergence and therefore yield** potential
*Planting into adequate soil tilth is critical. Every cotton seedbed must be pupae-busted after harvest. Tillage is then required to prepare a new seedbed that is free from clods and cotton stubble. (The type of machinery required and the number of cultivations depends on the soil type and its structure.) The biggest issue is managing time to prepare a seedbed that is in optimum condition for seed placement and emergence.

5. Plant Establishment
Key point: the best establishment scenario is a rain event that will provide sowing moisture (and initiate seed germination and seedling growth) once cotton harvest/bed preparation has been completed. This scenario is ideal in that it provides the best opportunity to achieve high yields (particularly if starting soil N levels are low). In this situation a uniform plant stand can be achieved; and the grower can then manage early season canopy growth and allow an irrigation to ensure secondary root development (see section 2).
* Pre-irrigation is risky due to the need to delay sowing if rain occurs. However, establishment may be better in a in a pre-irrigated paddock than a paddock that is dry-sown and watered-up.
*Profile completely dry at sowing? The only option is to plant shallow and water-up.
This is the least desirable option, particularly if starting soil-N levels are very high.
Often, in the water-up situation, plants still do not achieve secondary root growth and require further irrigation during tillering- which may create significant issues in terms of excessive early season biomass and tillering (thus creating a crop that's predisposed to lodging - particularly if starting soil nitrogen levels are in excess of plant requirements.)

6. Variety Choice
Key point: on average durum wheat has consistently yielded 1t/ha higher than bread wheat in northern irrigated wheat trials (on low soil-N sites)
* Durum varieties such as Bellaroi and Caparoi provided the highest yield potential and lodging resistance in 2011.
* Durum variety Hyperno has high yield potential, but is prone to lodging.
* Quick maturing varieties such as Kennedy and Longreach Crusader are the most likely APH (Australian Prime Hard) bread wheat varieties to achieve high yields, although Longreach Crusader has shown significantly more lodging resistance than Kennedy in high-N paddocks.

7. Water Budgeting
Key point: when undertaking a water budget; determine plant available water to a soil depth of 90cm.
* To maximise yield allow the wheat crop (from stem elongation stage) to source its entire soil water requirement from a soil depth of 90cm only.
* Depending upon in-crop rainfall, maximum yield may require up to 5 subsequent spring irrigations.

8. Winter irrigation
Key point: the largest early season issue in the northern growing region is achieving adequate secondary root growth, post-sowing.
* Early secondary root development will enhance water and nutrient uptake.

11. Overview of Project Achievements

* Dry soil moisture below the sowing depth of seed will prevent the growth of secondary roots.
* Soil moisture status should be assessed at 25-30 days after emergence, and if necessary, a winter irrigation applied to ensure healthy secondary root development in low soil-N paddocks only. (However if the paddocks' starting soil-N is high, then this irrigation is not recommended, as it may create early season crop canopy issues).

9. Spring irrigation
Key point: identify the fields' refill point to schedule irrigations and minimise water stress
* Use of soil moisture monitoring equipment is recommended. Soil moisture data will help identify the refill point (usually when 50 per cent of plant's available water has been depleted) and allow irrigations to be timed between stem elongation (Z31) and the mid-dough stage (Z80) to minimise crop stress.
* At the mid-dough stage soil moisture needs to be reassessed to determine if a further irrigation is required. Correct timing of the last irrigation will ensure adequate grain fill and reduce the risk of lodging and harvesting delays.

10. Limited water-supplementary irrigation
Key point: the best timing for a single in-crop irrigation of around 1 ML/ha is during early to mid-stem elongation
* While head emergence is the most sensitive growth stage to a short severe water stress, the best timing for a single irrigation is one that spreads the water across a number of growth stages.

11. Available soil phosphorus at sowing
Key point: in low soil-N post-cotton paddocks, starter fertiliser will improve establishment
* Sample representative paddocks to determine starting soil-N and P (N at 90cm depth, P at 20cm).
* For wheat grown after cotton use 10-20 kg P/ha as starter-fertiliser.

12. Nitrogen application strategy
Key point: at least 275** kg N/ha is required to grow 8t/ha of wheat
*The success of nitrogen application strategies will vary depending on soil type, irrigation system, sowing soil moisture and can change with the rainfall and temperatures received during tillering.
*The minimum sowing soil-N required to achieve maximum yield has varied in trials from 15 to 120 kg N/ha measured to a depth of 90cm.
*Total soil nitrogen requirements when targeting maximum yield are 250kg N/ha.
*N can be split-applied in low soil-N paddocks (some fertiliser will be required at sowing)
*In high-N soils nitrogen fertiliser requirements are more safely applied at stem elongation (growth stage 31) - ideally before rainfall or irrigation.

13. Use of Plant Growth Regulators (PGRs)
Key point: use of PGRs is still being researched for wheat
*The best response to use of PGRs in wheat has come from one application at stem elongation (GS 31) stage
*PGR use is recommended particularly in high soil-N paddocks.
*Carefully check label registration. Alternative products may soon be available.
*Further research is required on single (versus spilt) application in combination with delayed N strategy.

14. Disease Management
Key point: the profitability of fungicide application increases in high-yielding irrigated wheat; particularly if varieties have disease ratings lower than moderately resistant (MR).
* A pre-planned strategy of fungicide application based on growth stage and emergence of the top three leaves provides greater margin returns when susceptible wheat cultivars are subject to disease.
* Aim to apply a fungicide at flag leaf emergence (GS39). This should be preceded by a GS31-32 spray where disease onset is early or where susceptible cultivars are grown with no upfront protection.
*Consider an additional ear-emergence fungicide where stem rust (Puccinnia graminis) is the primary disease target or, a first-flower spray where wheat or durum is at high risk of Fusarium head blight.

12. Conclusions

There are significant benefits to both the grains and cotton industries from the development of a water use efficient, highly productive winter cereal crop option for irrigation. A cropping system where there is a combination of winter and summer cropping will reduce overhead costs, spread risk, increase the farm's overall water use efficiency, reduce the likelihood of herbicide resistant weeds, increase the efficiency of storing soil moisture, assist in maintaining soil quality and ultimately, increase profitability. There are approximately 600,000 hectares developed for irrigation in the cotton growing regions. It is estimated that of this (in non drought conditions) annual cereal plantings are 85,000 hectares. When cotton prices are high history shows growers will use available water on cotton. However if production risks are eliminated for "high input" irrigated wheat it will provide the basis for an improved cotton farming system. A cereal crop using less irrigation water than cotton can improve farm profitability when cotton prices are low.
If cotton growers adopt an equally professional approach to the agronomic management of irrigated wheat than $return/megalitre can be improved. However even if wheat is not irrigated or sparingly irrigated yield improvements can be made by adopting recommendations that have been developed for the northern region to reduce lodging risk.

13. Recommendations

This project has taken the opportunity to document commercial and research experience developed since 2007 to grow high yielding irrigated wheat.
It is now known that there are different but critical management decisions in growing high yielding irrigated wheat in high or low soil nitrogen paddocks. The key is to know the paddock's starting soil-N levels, and to then adjust water and nitrogen availability during the growing season.
Fourteen key project recommendations have been produced from 2 projects- High Yielding Irrigated Grains in Cotton Farming Systems (HYIGCFS) and Achievable Yields (AY).
Key recommendations to manage plant growth and to reduce the risk of lodging have now been incorporated in the booklet "Irrigated Wheat --Best Practice Guidelines in Cotton Farming Systems". **See Appendix 1**
It is a first for the northern region.

14. Other Research and Development Opportunities

Identified Research Gaps

*investigation into the causes of lodging—reduced light penetration or shading (as a result of excessive early biomass and dead tillers)

*stem strength x N interaction –can high soil-N be managed by delayed irrigation to GS31

*identification of varieties suitable for the northern region that have high yield and high straw strength (best to date e.g. Sentinel {feed} EGA Bellaroi {durum})

*minimum plant populations required for maximum yield target (see Breeza 2011 results)

*research into winter irrigation requirements for secondary root development

* review wheat variety response on 15, 30 or 45 cm row spacing (4,6 or 12 rows on a 1.8 metre bed) on low fertility (after cotton) targeting high yield level (8t/ha+).

* research into new PGR products and timing of application for best available varieties

* equipment /practices recommended to get from large stubble load remaining from high yielding wheat crop back to cotton rotation.

15. Attachments

16. Management of Intellectual Property/Commercialisation

Provide a summary of any strategies undertaken or planned to facilitate the protection and / or commercialisation of the project's realised outputs

The booklet produced "Irrigated Wheat--Best Practice Guidelines in Cotton Farming Systems " has a copyright

Some Ph.D. findings have been incorporated into the guidelines as supporting data -- approval was sought to ensure there is no impact on the submission of the Ph.D. thesis.

Provide a list of all scientific or technical papers published, and any patents filed

*Griffiths.B, etc Practical considerations and agronomic management for winter cereal cropping in the western regions of northern New South Wales and southern Queensland
*Gett.V. Establishing Irrigated Wheat following Cotton in Northern NSW.
*Griffiths.B,etc Addressing agronomic constraints in irrigated wheat production in the northern grain region.
*Jackson.R, etc. Improving irrigated wheat yields and water productivity in the northern cropping region of eastern Australia.
*Scheer, C., etc. Nitrous Oxide emissions from irrigated wheat in Australia: impact of irrigation management. Agriculture Ecosystems and Environment
*Payero, J.O.,etc Comparison of irrigation and nitrogen management strategies for wheat production in the Australian northern region.
*Irrigation Guide for Wheat in the Australian Northern Region (WaterPak)

Provide a list of any confidential information, if relevant and attach details to this report

N/A

17. Details of International Collaboration

Did this project have international collaboration?

No ☑

Yes ☐ Provide details of the international collaborating organisations/people below

Provide details of the international collaborating organisations/people below

N/A

Detail the nature of the international collaboration

18. Please use this area to include any additional text to support your report. Please do not include images. You may also attach a document (e.g. Word, Excel, PDF) limited to a maximum of 5 x A4 pages to this Report. Any additional information will be viewed as supplementary data. The report will only be evaluated on the previous sections of this document.

Relevant project data and irrigated wheat recommendations have been summarised in the booklet "Irrigated Wheat-Best Practice Guidelines in Cotton Farming Systems". It is readily available on the Cotton Catchment Communities CRC and GRDC web sites. 2,500 hard copies have been printed and distributed in the northern region.

Final Report

19. Plain English Summary for Public Release

Project Title:	**High Yielding Irrigated Grains in Cotton Farming Systems**
GRDC Project No:	**CCC00004**
Primary Contact:	Mr John Sykes
Organisation:	Cotton Catchment Communities CRC Locked Bag 1001 Narrabri NSW 2390 Australia
Phone:	02 67 991512
Fax:	02 67 93 11 71
Email:	nubeni@bigpond.com
Objectives	Research to reduce the impact of lodging in high yielding/high input irrigated wheat was urgently needed in cotton farming systems. The focus was on management areas that effect canopy growth and eventually yield potential: establishment, agronomy/nutrition, canopy management, disease management and irrigation timing /frequency.
Background	Yield decline in back-to-back cotton is well documented. Crop rotation is the key to irrigators achieving the productivity improvements on offer in cotton. Rotation crops that are profitable in their own right present the opportunity for more dynamic cropping systems to evolve and will enhance the resilience of irrigated cropping enterprises to seasonal fluctuations in commodity prices and irrigation allocations. While cotton production in rotation with winter cereals is already common place, the majority of cereal crops currently grown are achieving low/inconsistent yields and are only in part delivering the profitability and the rotational benefits to the system that are possible. Irrigation has not routinely been allocated to these crops, but rather, has occurred if there is water remaining on farm at the end of the summer irrigation season. "High Input" wheat is characterised by full water and nitrogen allocation (5ML water /ha as soil moisture, in-crop rainfall and irrigation + split applications of nitrogen budgeted to achieve 8 t/ha).While high yields do occur, this production system is currently viewed as high risk due to crop lodging and is not routinely adopted by cotton growers. In 2007 management recommendations were based on southern NSW irrigation experiences. However the northern region environmental conditions are different to southern irrigated areas, particularly the shorter time available during grain fill period. In 2008 when cotton prices were low growers increased inputs but irrigated wheat crops failed because of the impact of lodging.

Grains Research & Development Corporation

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Research	The RDE Approach evolved as follows: (1) Review southern NSW and international literature to extrapolate management guidelines for modification in the northern region. (2) Undertake extensive case studies in 2008 and 2009 to document current practices and experiences. Conduct on-farm demonstrations in the same years with simplified research treatments. (3) Commence a trial program in 2010 and continue in 2011. The nature of work alters each year as information from the previous year/s is used to refine the focus on key issues. The key concurrent activities are based on: a) Sowing configurations - planting rates x row spacings. Assessments will include; pre- Vs post-flowering water use via neutron probes, radiation interception of the canopy via a plant canopy analyser, production of tillers Vs viable heads, yield and grain quality at harvest. b) Nitrogen application - timing and rate of nitrogen to modify canopy growth. c) Wheat response to applied irrigations - irrigation scheduling based on depletion of 50% PAWC Vs 60% PAWC Vs 70% PAWC Vs 85% PAWC (in collaboration with lysimeter studies). Assessments will include; evapotranspiration via weighing lysimeters, applied irrigation, rain, weather variables, weekly soil water profile via neutron probes, canopy radiation interception, leaf area index, crop yield and grain quality at harvest. (4) Develop a new web-based decision support tool. This tool will be designed to provide optimal solutions to the allocation of water and land across a number of cropping enterprises e.g. cotton, wheat, corn. This tool will be accessible from the APSIM/QPIF web site, it will be simple and generic enough for any grower to use after limited training. The calculations will be based on limited farm business information and optimisation routines. The model will optimise land allocation per crop type, assess sensitivity to changes in seasons, expected yields, expected commodity prices, and water allocation. (5) Extension is primarily through the distribution and promotion of the booklet "Irrigated Wheat--Best Practice Guidelines in Cotton Farming Systems"

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Outcomes	Project outputs delivered establishment, nutrition and irrigation guidelines for irrigated wheat. Information on canopy and disease management from the Achievable Yields project (Allan Peake--CSA00017) complimented these management areas. Results from both projects have been incorporated into a single booklet --"Irrigated Wheat--Best Practice Guidelines in Cotton Farming Systems". The project carried out case studies, grower workshops, detailed research trials and APSIM modeling to develop recommended practices. Best Practice Guidelines were provided to agronomists/consultants before release for review but the majority of suggested change came from editorial staff at the Cotton Catchment Communities CRC and GRDC and from project team members. This was to ensure the booklet was published in a format easily accessed and then regularly used as a leading management resource.

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Implications	There are significant benefits to both the grains and cotton industries from the development of a water use efficient, highly productive winter cereal crop option for irrigation. A cropping system where there is a combination of winter and summer cropping will reduce overhead costs, spread risk, increase the farm's overall water use efficiency, reduce the likelihood of herbicide resistant weeds, increase the efficiency of storing soil moisture, assist in maintaining soil quality and ultimately, increase profitability. There are approximately 600,000 hectares developed for irrigation in the cotton growing regions. It is estimated that of this (in non drought conditions) annual cereal plantings are 85,000 hectares. When cotton prices are high history shows growers will use available water on cotton. However if production risks are eliminated for "high input" irrigated wheat it will provide the basis for an improved cotton farming system. A cereal crop using less irrigation water than cotton can improve farm profitability when cotton prices are low. If cotton growers adopt an equally professional approach to the agronomic management of irrigated wheat than $return/megalitre can be improved. However even if wheat is not irrigated or sparingly irrigated yield improvements can be made by adopting recommendations that have been developed for the northern region to reduce lodging risk.

20. Scientific Report for Public Release

Are you required to submit the Scientific Report for Public Release for GRDC Progress and Final Reports?

No ☑

Yes ☐

Use the section headings shown below:

Abstract:
Introduction:
Materials and Methods:
Results:
Discussion:
Conclusion:
Appendices:
Acknowledgements:
References.

Step 1: **Click to go the template on our website**

Step 2: **Attach this Scientific Report to the Progress Report**

21. PRIVACY

The personal information you supply will be held on a database by the GRDC. The information held by the GRDC may also include your particular field of interest and in some cases details of some research projects undertaken. Third parties, such as researchers, federal and state agencies, growers and other members of the public, sometimes ask the GRDC to provide contact details. It is the GRDC's usual practice to pass on the information if it is satisfied that it is for legitimate industry or research purposes.
If you do not want to have your contact details disclosed in these circumstances, please inform us by ticking the box below.

No ☐

22. Certification

Reports to the GRDC should be made by the organisation conducting the research and coordinated through their central administrative area. For example, tertiary education institution reports should be processed through the Registrar or Bursar's office. Ensure the Certification details are complete before the form is submitted electronically. The electronic copy received by GRDC will be the copy that is evaluated.
Ensure that one hardcopy of the electronically submitted form is signed by the Project Supervisor and a duly delegated representative from the research organization.

Send this hardcopy to the GRDC (**Contracts Coordinator, GRDC, PO Box 5367, Kingston ACT 2604**) by the published closing date.

Project Supervisor's signature	Name	Date
	JOHN SYKES	18/05/2012

Research organisation signature	Name and title of authorised signatory	Date
[signature]	PHILIP ARMYTAGE CEO	18/5/12

Date last changed
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Publications	Peake AS, and Angus J.F. (2009). Increasing yield of irrigated wheat in Queensland and Northern NSW. In GRDC Northern Region Grains Research Updates, Goondiwindi, 3-4 March, 2009. (Available on GRDC website) *Peake A.S., Rebetzke G., Chapman S., Dreccer F, McIntyre L and Hundt A (2012). Agronomy for high yielding cereal environments: varieties, agronomic strategies and case studies. In GRDC Northern Region Grains Research Updates, Goondiwindi, 6-7 March, 2012. (Available on GRDC website) *Griffiths.B, Guppy.C, Hulugalle.N, Birchall.C, Bailey.L (2011) Practical considerations and agronomic management for winter cereal cropping in the western regions of northern New South Wales and southern Queensland. (Available on GRDC website) *Griffihts.B, Gett.V, Jackson.R, Burley.T, Harris.G, Payero.J. Addressing agronomic constraints in irrigated wheat production in the northern grain region. (Cotton CRC Science Review March 2012 in-print) *Gett.V. Establishing Irrigated Wheat following Cotton in Northern NSW. 16th Australian Agronomy Conference (in press) *Jackson.R, Griffiths.B, Gett.V, Burley.T, Harris.G. Improving irrigated wheat yields and water productivity in the northern cropping region of eastern Australia. (2012 IAL Conference-in press) *Scheer, C., Grace, P., Payero, J.O. et al. Nitrous Oxide emissions from irrigated wheat in Australia: impact of irrigation management. Agriculture Ecosystems and Environment (in press) *Payero, J.O., Robinson, G. and Harris, G.A. Comparison of irrigation and nitrogen management strategies for wheat production in the Australian northern region. Field Crops Research (submitted for publication) * J.O. Payero, G. Harris, R. Jackson (2012). Irrigation Guide for Wheat in the Australian Northern Region (WaterPak) (in press)