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Cotton Research and Development Corporation

COMMISSIONED PROJECT 2012–13

Moving in and out of cotton

Identifying farming systems issues in western NSW irrigation areas (Proposal 2)

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Moving in and out of cotton – Identifying farming systems issues in western NSW irrigation areas (Proposal 2)

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More information

John Sykes, Contractor, NSW DPI

Tim Weaver, Sales Agronomist, Cotton Growers Services, formerly District Agronomist NSW DPI, Walgett

Rob Hoogers, Irrigation Development Officer Southern Broadacre, NSW DPI, Yanco

www.dpi.nsw.gov.au

www.crdc.com.au

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Cotton Research and Development Corporation

CottonInfo

Boyce Chartered Accountants

Cotton Growers Association

Cover image: Paul Fisher (Boyce Chartered Accountants), John Sykes and Janelle Montgomery (NSW DPI) inspecting camera and weather recording equipment. Image source: Tim Weaver.

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List of Acronyms

NSW DPI – New South Wales Department of Primary Industries

CRDC – Cotton Research and Development Corporation

GRDC – Grains Research and Development Corporation

CSIRO – Commonwealth Scientific and Industrial Research Organisation

ACRI – Australian Cotton Research Institute

RDE – Research, Development and Extension

WUE – Water Use Efficiency

GDD – Growing Day Degree(s)

DD – Day Degree(s)

CA – Cotton Australia

CSD – Cotton Seed Distributors

CGA – Cotton Growers Association

ACCA – Australian Cotton Comparative Analysis

GPWUI – Gross Production Water Use Index

IWUI – Irrigation Water Use Index

CWUI – Crop Water Use Index

IAA – Irrigation Association of Australia

GPS – Global Positioning System

List of Definitions

CottonInfo – Cotton extension funded by CRDC/CSD/CA

CottASSIST – Set of web tools to help growers/agronomists with cotton management decisions

SILO – an enhanced climate database hosted by the Science Delivery Division of Department of Science, Information Technology, Innovation and the Arts (DSITIA)

Executive Summary

In 2012–13 NSW DPI undertook a nine month benchmarking project in the western NSW irrigation production region commissioned by the CRDC.

The aims of this project were for key NSW DPI agronomists to further develop technical skills in cotton growth and development and provide linkages to industry partners in the new production areas of NSW. CRDC required NSW DPI to add value to existing projects, build grower participation in the western region, provide economic insights and develop agronomic management information for cotton industry extension services.

This project facilitated linkages to other projects focused on water use efficiency benchmarking (NSW DPI), cotton comparative analysis (Boyce Chartered Accountants) and growing day degree modelling (CSIRO).

NSW DPI facilitated data collection on six farm sites. Activities focused on collecting temperature and plant growth data to help validate day degree modelling for western NSW, collecting WUE data, agronomic management of crops, facilitating field days and meetings with growers and coordinating the development of future research, development and extension issues.

Major recommendations from the project are:

1. Establish a RDE committee to coordinate on-farm activities with CA/CRDC/CSIRO/NSW DPI/CSD/Companies/GRDC.
2. Conduct a storage survey to obtain an accurate depth-to-volume and surface area relationship on the Walgett properties to gain an accurate measurement of water volumes in individual storages.
3. Improve the availability of local day degree data for plant growth in western NSW.
4. Establish on-farm trials that are linked to trials conducted on research centres with coordinated scientific input.
5. Establish a set of standard trials (on-farm) coordinated across different locations to track and measure where the nitrogen (N) goes under different timing regimes to help develop best practice options.
6. Install weather stations and in-field time lapse cameras at each trial site to monitor climatic conditions and day degrees during the cotton season.
7. Provide on-going encouragement (by CottonInfo staff) to western growers, advisors and financial institutions to collect data for ACCA (Boyce CA).
8. Encourage CRDC to utilise the opportunity to link NSW DPI research and development staff to the cotton industry in western NSW through WUE research and experience in northern rivers irrigation areas.

Four major RDE issues were prioritised by industry in March 2013. These were:

- nutrition (N, P and K) – when to apply, key growth stages, how to apply, quantities
- irrigation scheduling – the effect of pushing out irrigation at key growth stages
- back to back cotton – impact on yield
- genetics of heat tolerance.

Background to Western NSW Irrigation Areas

- Cotton is irrigated using water from the Namoi and Barwon rivers. On-farm storage is a key requirement enabling water storage from high river flows. Cotton has been grown in the Walgett shire since 1980 (J Moore, pers. comm., 2013). A current estimate of the area sown to cotton is 12,000 ha. This fluctuates with high flow water availability in the Barwon River and is tempered by evaporation losses from large area storage systems and low cotton prices. The fertile Walgett soils, combined with the hot, long and relatively dry summers, allow cotton producers to achieve high yields and quality. An average yield for cotton within the Walgett shire is 10.5 bales/ha (S Logan, pers. comm., 2013).
- Western irrigators are opportunity irrigators and will continuously crop cotton whilst they have water and cotton prices are high (>$450/bale). The major agronomy research issue is nutrition management that will simulate break crop cotton production.
- The key areas for sustainability of cotton production in western NSW are:
  1. Irrigation water availability, evaporation losses from water storages and channels, and costs including diesel and electricity to extract water and lift it through channels.
  2. Soil nutrition and the timing of application. This is the highest priority as listed below.
  3. Price of cotton will determine the sustainability of cotton growing in the western regions.
  4. Licensing of the transgenic varieties. This is very costly to growers. Maybe other competition needs to be available to reduce this price e.g. Liberty Link cotton.
  5. Volunteer cotton. This is a big issue when licensing requires all previous season's crop to be destroyed. Many paddocks observed in this project (2012–13) had rows of volunteer cotton.
  6. Development of profitable rotation crops. Legumes are a source of nitrogen and a disease break crop.
- There is no local RDE reference group but a local grower sits on the CA Research Advisory Panel.
- There is a strong and active CGA group and recently irrigation areas have been developed by young and enthusiastic growers. A CottonInfo industry development officer has been appointed by CSD/CRDC/CA in 2013. Region-wide nutrition trials are being planned for 2013–14, coordinated by CottonInfo staff with CSIRO scientific input.
- The Walgett CGA was interviewed regarding their role. In summary, their goals for cotton production are very much aligned with the new five year strategic plan developed by Cotton Australia to improve yields and remain profitable with research development and extension driving continual improvement. The local issues are water use efficiency, protecting the industry from disease,

pests and weeds, and managing nutritional requirements to keep up with demands of the cotton plant without degrading the soil. The local emphasis is on continuing water supply and supporting extension from research in the above areas, that is increased presence and linkages to national and local RDE projects.

- There is potential to initiate RDE projects through negotiation with research scientists employed by CSIRO and NSW DPI in partnership with CRDC (and GRDC). Currently there are two projects; this commissioned research project and one sub-project in the Walgett shire 'Validate and extend the IrriGATEWAY irrigation management tools into the cotton industry' (CLW1101, CSIRO, Griffith NSW).

Project Milestone Reports

In 2012–13, six farm sites were selected to value add to current CRDC projects focused on WUE, cotton comparative analysis and day degree modelling. They were geographically separated (Figure 1). Some were relatively new irrigation developments and all were owned and operated by young and enthusiastic growers.

1. WUE Benchmarking in Western Irrigation Areas (in conjunction with NSW DPI)

Reduced water allocations have resulted in irrigators needing to use their water more wisely as they continue to aim for maximum return per megalitre. There is also increasing pressure from the Australian public on irrigation industries to measure these improvements in water use efficiency. The cotton industry has borne heavy criticism for its water use and has therefore been proactive in assessing its water use efficiency.

In 2008, NSW DPI gained funding to rectify the lack of 'robust benchmarking data' allowing benchmarking of irrigation water use for the 2006–07 cotton season using WaterTrack Rapid™. Benchmarks have since been established for the 2008–09 and 2012–13 cotton seasons.

WaterTrack Rapid™ is an online benchmarking tool that calculates various water use efficiency performance indicators. The program also estimates crop water use and on-farm water losses. The process is simple and quick and, more importantly, utilises a consistent approach allowing on-farm water use to be compared across the industry. The calculation of the water use indices has been standardised and enabled meaningful comparison.

CRDC required data collection to be extended to the western and southern production areas to further enable the irrigation industry to show the rate of improvement in water use efficiency and to also identify potential performance targets.

At a grower level, irrigation benchmarking is also necessary if an enterprise is going to improve its water use efficiency. Being aware of how you are performing compared to your region or industry enables continuous improvement in water management.

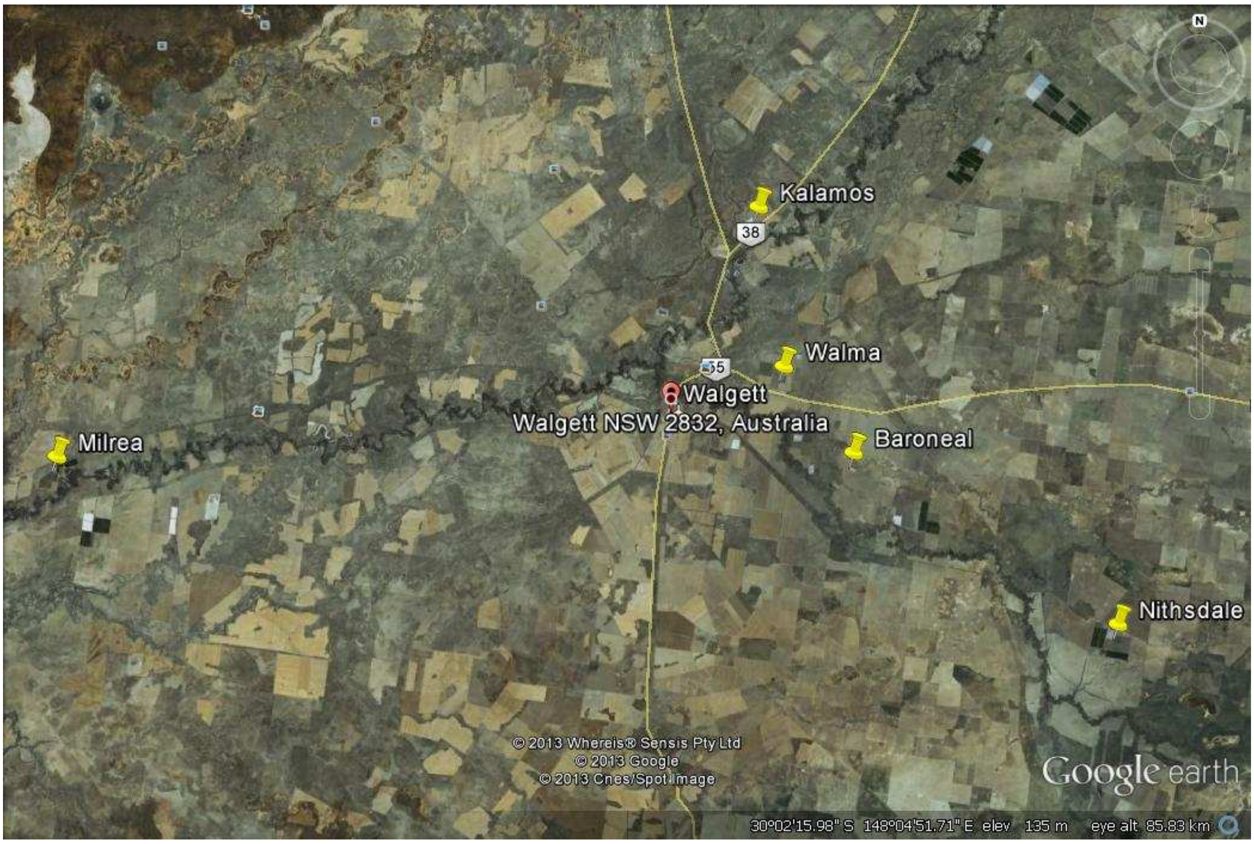

Figure 1 Location of the five farm sites.

Source: T Weaver, NSW DPI

Methodology

The data collected includes cotton yield, water inputs (including rainfall, soil water, storage volumes, water harvested on-farm, irrigation water pumped), irrigation dates and soil type based on water holding and infiltration characteristics.

The WaterTrack Rapid™ program generates a water summary report and performance indicators report. See Appendix 1.

WaterTrack Rapid™ automatically downloads FAO56 method evapotranspiration (ETo) and rainfall data from the Australian Bureau of Meteorology SILO site. To determine crop water use (ETc), the WaterTrack Rapid™ calculator uses ETo (reference crop evapotranspiration) values from SILO with a set range of cotton FAO56 method dual crop coefficients. Where possible, actual farm rainfall records were used rather than SILO rainfall figures. Effective rainfall is calculated based on the US Department of Agriculture rainfall run-off model.

Crop water use provides an estimation of the amount of water required per hectare to produce the crop in that season. Total available water losses are calculated by subtracting the theoretical crop water use from the total amount of water used on-farm to grow the crop.

WaterTrack Rapid™ combines all on-farm water losses into a single figure. These losses include:

- all seepage and evaporation losses from supply systems, ring tanks and dams, drainage and tail water systems
- in-field losses such as evaporation from the soil surface and deep drainage
- rainfall run-off that is not harvested.

A number of irrigation performance indicators are calculated including gross production water use index (GPWUIeffective, farm), irrigation water use index (IWUIfarm) and crop water use index (CWUI).

Results

Figure 2 shows results from six cotton farms located in the Walgett District, ranked by total water loss per hectare. Crop yield (bales/ha), total water supplied (irrigation water (ML/ha)) and total available water (irrigation water + effective rainfall + soil moisture used (ML/ha)) and crop water use (ML/ha) are also presented.

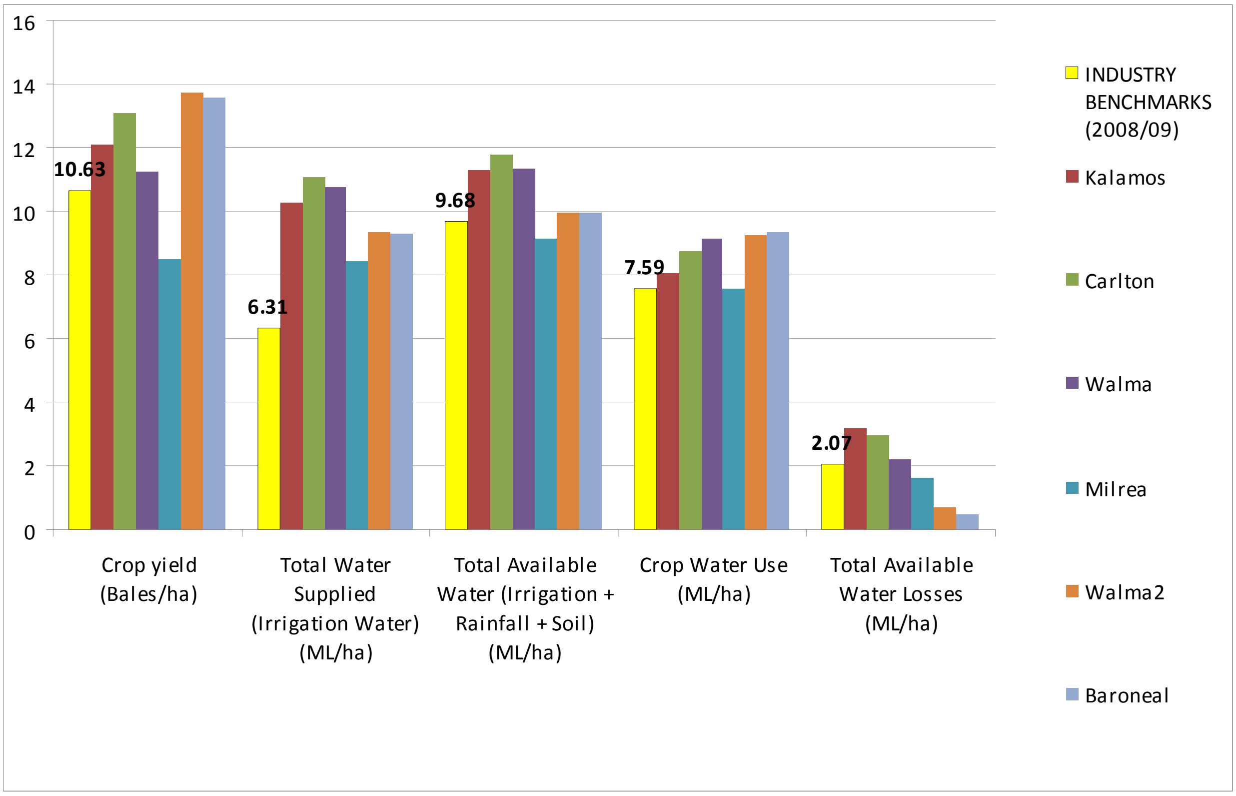

Figure 2 Variation in total available water loss compared to yield, total water supplied (irrigation water), total available water (includes water diverted, harvested, used from storages, rainfall and soil water) and crop water use.

The industry averages are taken from benchmarks established in 2008–09. All farms, except one, achieved yields above the industry average, ranging from 12.04 to 13.7 bales/ha. Milrea had a disappointing yield (8.4 bales/ha) due to low water availability, stretching irrigations, volunteers and back to back fields (J Murray, pers. comm., August 2013). The productivity of this crop is reflected in relatively low crop water use compared to the other crops. Crop water use was 7.57–9.37 ML/ha (average 8.69 ML/ha) which is equivalent to a total of 869 mm for the season. This high crop water use reflects the high temperatures and evaporative demand experienced during the 2012–13 season.

On average, the total amount of water used on-farm to produce the cotton crop was 10.57 ML/ha, ranging from 9.14 to 11.78 ML/ha (shown as total available water in Figure 2). Most irrigators indicated that the first irrigation took a lot of water (up to 2 ML/ha) and extra irrigations were required due to little rainfall and hot weather prior to Christmas.

On-farm water losses averaged 1.87 ML/ha. This was around 17% of all water used on-farm for the crop and included water diverted from the river, water harvested on-farm, effective rainfall and stored soil moisture used during the season. Therefore on average, the farms were able to use approximately 80% of their water productively through the plant.

Three water use indices—CWUI, IWUIfarm and GPWUIeffective, farm—calculated for each farm are presented in Figure 3.

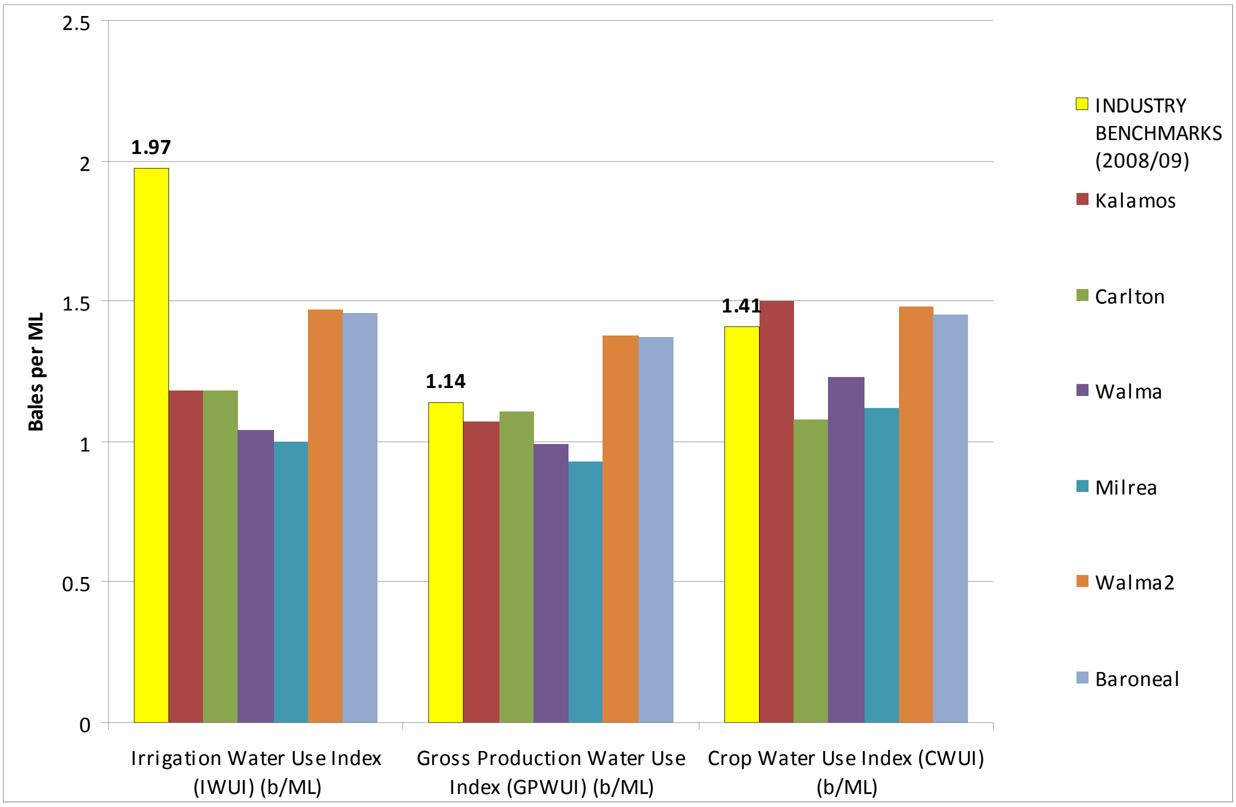

Figure 3 A Comparison of the water use indices for Walgett Farms calculated using WaterTrack Rapid™.

IWUIfarm relates total production to the amount of irrigation water supplied only. The average IWUIfarm was 1.22 bales/ML, ranging from 1.0 to 1.47 bales/ML. The industry benchmark established for the Australian cotton industry for the 2008–09 season is significantly higher at 1.97 bales/ML. However, in-crop rainfall was much higher in 2008–09 so less irrigation water was used to produce the crop. The 2012–13 season at Walgett was extremely dry with little in-crop rainfall and as a result, irrigation water made up on average 93% of total water supplied to the crop whereas in 2008–09, the average irrigation water supplied was only 64% of total available water.

The differences in the IWUIfarm in these two seasons illustrate the influence that rainfall has on this index. IWUIfarm can be used to compare between nearby fields or farms in the same season but as rainfall is not included it is not useful for comparing over significant distances or between seasons.

A more meaningful water use index for comparing irrigation water use between farms and regions and across seasons is the gross production water use index (GPWUIeffective, farm). It relates total production to the total amount of water used from all sources (irrigation water, effective rainfall and soil moisture). The average GPWUIeffective, farm was 1.14 bales/ML, ranging from 0.93 to 1.38 bales/ML. Three farms fell below the industry benchmark. The two farms that had a GPWUIeffective, farm higher than the industry benchmark included Baroneal and Walma2. Both farms achieved high yields (>13 b/ML). Baroneal had only one field planted to cotton, no on-farm water storage and as they were only irrigating one block, very low seepage and evaporation losses from the field and conveyance system.

CWUI relates total production to the amount of water consumed by the crop (ETc). Although it is not a useful index for irrigation benchmarking, it is useful for estimating potential crop water use and for comparing crop productivity. The average CWUI was 1.31 b/ML and ranged from 1.08 to 1.50 b/ML. See Appendix 1.

Each property is summarised below:

Carlton:

- 319 ha cotton (larger farm, extra irrigations)
- One storage of 40 ha (capacity 1900 ML)
- Four fields and 13 irrigations (including 11 in-crop, water-up and flush) compared to 10 or less irrigations for other farms
- Takes up to a week to irrigate the whole farm so there is greater opportunity for seepage and evaporation losses compared to smaller farms
- Had lower starting moisture and the profile dried out more at the end of the season compared to the other farms. The change in soil moisture was -0.35 ML/ha (negative meaning an increase in soil moisture). A Walgett consultant suggested that given the initial water used by other growers, they too would have had similar starting moisture, so perhaps drier than the report (S Logan, pers. comm., 2013).

Kalamos:

- 142 ha cotton
- One storage of 40 ha (capacity 1350 ML) and 2 lagoons (total capacity 500 ML)
- Three fields; field 3 had 8 irrigations (including water-up) and fields 1 and 2 had 9 irrigations
- The crop appeared to be delayed in the initial stages but improved quickly
- Ran out of water near the end of season so decided to finish the crop early
- Relatively inefficient water distribution system
- The tail water goes into shallow lagoons before it is pumped back up to a large storage located some distance from the field. It is a long distance to move water through the recirculation system and there is more potential for losses through evaporation and seepage. Evaporation losses from the lagoons and storage are likely to be quite high as they are relatively large and shallow. There are also some issues in fields with falls and holes that would affect application efficiency and field drainage.

Walma:

- 242 ha cotton
- Two storages; storage 1 is 28 ha (capacity 600 ML) and storage 2 is 24 ha (capacity 500 ML)
- Five fields; field 25 had 11 irrigations, fields 28, 29, B3 and B4 had 10 irrigations
- Poor emergence initially (a lot of grass in the initial stages that was sprayed with Roundup). The crop was delayed in comparison to Baroneal.

Walma2:

- 227 ha cotton
- Three storages; storage 1 is 45 ha (capacity 900 ML), storage 2 is 8 ha (capacity 250 ML) and storage three is 8 ha (capacity 250ML)
- Six fields that had ten irrigations.

Baroneal:

- 61 ha cotton
- No storage – uses Walma2
- Single field

Walma, Walma2 and Baroneal:

- Small blocks with very tight watering regimes. They keep fields close together each year and can generally irrigate the whole farm in less than 48 hours (compared to larger farms such as Carlton).
- Tail waters are kept to a minimum.
- Baroneal is a single block whose water comes from Walma2 and tail waters returned to Walma2 storage.
- Baroneal tail water is held in lagoon storage and the water is conveyed via a channel from Walma2 and dropped into the lagoon. The water is then lifted out of the lagoon and pumped into a channel that goes around the paddock and then lifted into the head ditch. This could account for some significant water loss. Figures could be skewed for Baroneal given recirculation and water storage was not accounted for in figures provided.

Milrea:

- 142 ha cotton
- Storages are two shallow lagoons of unknown area; lagoon 1 is approximately 10 ha (capacity 300 ML) and lagoon 2 is approximately 25 ha (600 ML capacity).
- Five fields; fields 2, 4 and 7 had eight irrigations (including water-up), fields 3 and 6 had nine irrigations including water-up.
- Crop was slow to establish and didn't pick up. It was always behind the other crops in height measurements and nodes.
- Experienced water shortages, stretching irrigations and eventually couldn't finish the crop.
- The lagoons on Milrea are shallow so have the potential for large evaporation losses.

Application Efficiency

Furrow irrigation was used on all farms. Furrow systems are capable of high efficiencies (90%) on cracking grey clays but some measurements are required to indicate performance levels.

Improved water use efficiencies can be obtained by making small changes in management and these changes can have a significant impact on production and profit. The only way to maximise these efficiencies is to measure them.

Irrimate™ provides growers with simple tools to measure what is happening to their water at the field level to assess their irrigation performance on individual fields. Irrimate™ involves the actual measurement of the amount of water applied to the field using a flow meter that is attached to an existing siphon. The time the water takes to advance down the furrow is measured using six advance sensors evenly spaced down the field. Run-off is measured using a flume with a flume flow meter attached. The field slope and length and physical dimensions of the furrow are also measured. The data is then used to determine the soil's infiltration capacity. Surface irrigation relies on the soil's infiltration capacity and based on this, a computer model called SIRMOD is used to simulate the actual irrigation event. Once the model is calibrated with advance and run-off data, alternative management strategies can be assessed to optimise the irrigation event. Management options include changing the flow rate or time that siphons are running. The program can also be used to examine different scenarios such as different field length. The optimum application efficiency can be predicted by changing one or a combination of these management variables to establish the most efficient irrigation application strategy.

Over the 2006-07 cotton season, 30 irrigation events were monitored across five farms in the Moree district. Results were variable with a large range in the measured application efficiency (40–94%). The application efficiency is the volume of water stored in the root zone as a ratio of the volume applied to a field. Those fields with a high application efficiency were already optimised as the water was evenly applied down the field meeting the deficit with little deep drainage or run-off. Other events were improved by pulling siphons earlier or increasing the flow rate by maintaining a high level of head in the head ditch. Increasing the efficiency of irrigation events led to water savings of up to 0.35 ML/ha per irrigation. The average water savings from the optimised irrigation events was 0.13 ML/ha per irrigation. To put this into perspective, 400 ha and seven irrigations would amount to 364 ML. This could grow an extra 50 ha of cotton or provide 90% of the water required for one irrigation cycle on this farm.

Storage Management

Evaporation from on-farm storages is generally the largest loss of water on a farm. Walgett irrigators reduce water losses by using stored water early in the season, however supplementary water was available later in the season following significant rainfall that allowed most of them to fill their on-farm storages. See Appendix 2.

Most of the irrigators' storages have not been surveyed and have no calibrated gauge board to regularly read storage volumes.

Irrigators often make decisions based on how much water your storage can hold. Whether it is determining how much irrigated crop to plant at the beginning of a season, making the hard decision of ploughing crop in or benchmarking irrigation performance at the end of the season, it is frequently the amount of water in the on-farm storage that is referred to. So, what if your storage has more or less water in it than you think?

This project recommends a storage survey to obtain an accurate depth-to-volume and surface area relationship. This is essential if you want an accurate measurement of water volume in your storage. They can be carried out on dry storage or when it is full of water. After the storage is complete, a calibrated gauge board should be installed. Electronic storage meters are also available for continual logging of storage volumes.

Monitoring storage levels and volumes improves the accuracy of water budgeting and confidence in the scheduling strategy. Storage meters can also be used to accurately measure the amount of tail water and storm water you recover and can be used to check pump capacity when pumping directly into your storage. This can be achieved by taking a measure of storage level and volume before, and all inflow and outflow events. You should also account for any additional water due to rainfall and calculate losses due to seepage and evaporation. An electronic storage meter will continuously log storage volumes throughout these events. Real time data is available on the meter itself or via telemetry. Data can also be downloaded.

Storages losses (evaporation and leakage) should also be accounted for. Many storages are known to have leakage issues but often the actual magnitude of these losses has not been determined. Manual gauge boards can be used to provide some indication of losses (no real accurate volume) but they do not show the individual contribution of evaporation or seepage to the total loss. An electronic seepage and evaporation meter separates and records both of these components. This information can then be used when determining a water budget and ongoing in-crop scheduling. In situations where seepage is identified as a significant problem, this data enables a cost benefit analysis of potential remedial action.

2. Cotton Comparative Analysis in Western Irrigation Areas (in conjunction with Boyce Chartered Accountants)

Boyce Chartered Accountants has produced the annual Australian Cotton Comparative Analysis (ACCA) since the mid 1980s. It is widely regarded as an independent benchmark study for the industry that shows the income and expenses of growing fully irrigated cotton on a per hectare basis.

It can help farmers identify relative strengths and weaknesses and can be used as a management tool to implement change and identify where effort should be directed on a day to day basis. It has also provided all industry sectors with an annual review of the average farm net profit/loss.

In 2012, the total number of bales in the sample was just over 550,000, approximately 11% of total cotton production. Only a few growers from western NSW were included in the analysis and were combined with other valleys due to low participant numbers. The record size of the crop and the resulting delay in ginning made participation by growers difficult.

In 2012, the following industry highlights were identified:

- The value per bale is increasing ever so slightly—no real growth after inflation
- There is significant growth in costs per hectare
- These two statistics confirm decreasing terms of trade for the industry
- The yield per hectare is increasing but at a reduced rate
- The operating profit per hectare for the average grower is relatively static
- The operating profit per hectare for the top 20% of growers is increasing.

In 2012–13, CRDC engaged this project to help Boyce gain increased data sets in the (newer) western and southern irrigation production areas. Boyce is clearly affiliated with the industry and support must be continued. Ideally, 6–10 cotton enterprises are required to have a meaningful enterprise comparison in local areas.

This project identified and encouraged five growers to participate in the 2012 annual data collection. It proved difficult for Boyce staff to collect 2012 data. However this project recommends 2013 data collection can be further supported by:

- Selecting and endorsing eight growers via CGA that will contribute to an extra ‘western’ column in key tables. Annual data collection is seen as a long-term partnership as it time consuming and demanding on Boyce staff and clients. Time is needed to engage client bookkeepers/accountants and benefits have to be seen through discussion and influence on farm enterprises. A strong commitment and desire from clients is required for successful collection. Each situation must be negotiated as they are likely to vary.
- CottonInfo staff providing on-going encouragement to western growers, advisors and financial institutions. It is suggested a dedicated CGA/CottonInfo workshop be planned in November each year that is linked to profit. It would provide quality information on financial returns (Boyce), productivity (previous year yield analyses) and marketing.
- CottonInfo staff reviewing or developing a template to collect data in combination with bookkeepers/financial institutions to support data collection on dedicated farms.

3. Analysis of Crops Entered in CGA Crop Competition 2013

During May 2013, eight crops were inspected for the local crop competition. This proved an excellent tool to further develop RDE issues and complemented discussions at CGA meetings. It remains essential to investigate high yielding crops and this activity will be continued by CottonInfo staff. Additionally, CottonInfo will use this and other opportunities, for example scientific visitors, to bring together agronomists to review crop progress and management.

The data collected during the process showed the following trends:

- The variation in yield across the western region was due to several factors including farming practice (weed management and crop rotation i.e. back to back cotton which reduces yield), irrigation schedule (those short of water extended the period between irrigations) and soil chemistry (sodicity, chloride and salinity impacted on yield)

- The above mentioned factors were reflected in boll counts per metre (ranging from 136 to 164/m)
- The management of refuges (pigeon pea) also varied significantly across the western region. Crops that were short of water also reflected the quality of the refuge. Weed management within refuges varied significantly across the region as well.
- The crop competition had six criteria: estimated yield (for 2013, 6–12 bales/ha), boll counts (for yield estimation), weeds (farm and field), rotation, refuge and watering schedule. From the criteria a total score was calculated and the highest score was the winner.

This project supports the National Nutrient Management Trial Program coordinated by the CottonInfo team during the 2013–14 season.

4. Crop Growth and Development–Day Degrees (in conjunction with CSIRO and DAFF)

Written information is available on crop growth stages and cotton sustainable yield potential. To complement this information there is a good understanding of cotton plant growth stages by consultants to discuss management options in western NSW.

In 2012—13, collection of day degree data proved interesting at field days for all participants to reflect on seasonal comparisons and to stimulate discussion.

The major findings were:

- The normal range of nodes to first square is 4–7 (five is common). In western NSW in 2013, the average node number was nine (Table 1). This may be linked to high December and January temperatures and modelling based on older varieties and temperatures recorded at Narrabri.
- The normal range of day degrees from first square to first flower is 300–350. In western NSW the average was 235 at six on-farm sites (range 163–312).
- Overall, in western NSW in 2013, the day degree figure was consistent with the CottASSIST model for sowing to emergence but always higher for day degrees to first square, first flower and open boll (Table 1).
- The one-off temperature measurements in 2013 for western NSW indicated that temperature (and day degree accumulation) did not vary from the CottASSIST model but plant growth data did vary and needs to be compiled over a number of years, in different localities and linked to an experienced scientist to ensure there is rigorous validation of the CSIRO model.
- Growers showed great interest in temperature and plant growth data recorded on-farm and used it as a discussion point to compare crop progress and current research issues. It was appreciated that both cold shock at emergence and hot days during squaring and flowering adversely affected crop production in 2012–13. Day degrees are not widely used as a management tool to inform timely management decisions (nor should it have been in 2013).
- Day degree accumulation and plant growth stage identification would be valuable additions to data collection at CSD/NSW DPI/CSIRO on-farm research sites utilising the tiny tag technology. In 2013, this was successfully supported by installing a camera to capture a daily crop photograph (Figure 4).
- Initial reviews of available extension material on utilising day degrees for management purposes showed considerable improvement could be made to simplify information and provide better presentation for 'first time' agronomists and farmers.

Table 1 Summary of day degree data compared to CottASSIST predictions for five farms studied during the 2012–13 season.

Property	Node to first square	Days <=11℃ in first 20 days after sowing cold shock	>36℃ hot days in January	Emergence		First square		First flower		Open boll	
				Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
Nithsdale	9	8	15	95	106	783	562	1095	834	1789	1584
Kalamos	9	2	18	143	106	799	562	1036	834	1822	1584
Walma	10	7	19	99	106	843	562	1005	834	1763	1584
Baroneal	9	6	27	100	106	770	562	983	834	1803	1584
Milrea	8	5	24	105	106	775	562	1023	834	1815	1584

The accuracy of estimated day degrees (CottASSIST website) based on research in the 1970s is questionable. See Appendix 3.

Figure 4 First square at 9th node on 21 December 2012 at 'Walma'.

Source: Tim Weaver

This project recommends further scientific input to accurately document plant physiology in western NSW. It also recommends weather stations be installed at each trial site to monitor climatic conditions and day degrees during the cotton season. In this project, in-field time lapse cameras were invaluable in recording plant growth changes every 24 hours.

Future Agronomy Research Issues Identified

The day degrees summary (Appendix 3) was sent to all growers prior to a field day on the 6 March 2013 with a request to initially develop research issues. We then visited three sites to review crop agronomy issues and at the completion of the day future RDE issues were confirmed and prioritised by key growers and industry. Four RDE issues were developed and are listed below.

1. Nutrition (N, P and K) – When to Apply, Key Growth Stages, How to Apply and Quantities

- The Cotton Growers Association discussed the possibility of five core sites that could be soil sampled at key points in the rotation sequence and analysed. NutriLOGIC could be used for a database of information from the key sites to assist with crop status and recommendations for future cropping sequences.
- Reviewing the effect of legumes (faba beans would be ideal however early sowing time (April) conflicts with picking time) in the crop sequence. Pigeon pea was shown to have an impact on the following cotton crop.
- Back to back cotton and use of major and minor elements. There is still a shortfall of nutrients that are not provided by legumes. Using the soil analysis how do we best estimate the shortfall (NutriLOGIC database of five key sites)?
- Sodic (or chloride) sub soil limitations. Gypsum applications are too costly. Drying out and deep ripping may be an option. This may have to be studied separately.
- Is potassium a real issue? Demonstration trials and large scale trials (with replication) with CSD. Trials comparing legumes in rotation compared to fallowed trials.

Industry knowledge and findings on fertiliser use, particularly nitrogen, will come from the National Nutrient Management Trial Program being coordinated by CottonInfo during the 2013-14 season.

This project recommends the establishment of on-farm trials that are linked to trials conducted on research centres with coordinated scientific input. It also recommends a set of standard trials (on-farm) coordinated across different locations to track and measure where the N goes under different timing regimes to help develop best practice rates options.

2. Irrigation Scheduling – The Effect of Pushing Out Irrigation at Key Growth Stages

- Discussion about the number of hot days and having limited water during peak growth stages. Stretching out irrigation from 7–8 days to 8–10 days (irrigation scheduling trials), particularly the effects on boll development.
- CGA have identified that a survey of grower irrigation water storage capacities needs to be completed but the high costs involved mean this be carried out when storages are empty and local surveyors can be utilised. This will provide a basis for WUE studies.

This project recommends that CRDC utilise NSW DPI expertise in irrigation technologies and the comprehensive knowledge and understanding of northern irrigated farming systems. This can be linked by having joint sites investigating overhead irrigation WUE using the protocols developed by Rochester and Weir for the National Nutrient Management Trial Program.

3. Back to Back Cotton – Impact on Yield

- In 2013, there were excellent field comparisons of pigeon peas and fertiliser mixes with plant growth visibly better following pigeon peas. This needs further exploration in farming systems research.
- Current winter pulses (faba beans) do not always fit the sowing time requirements following cotton. There is a continued interest in irrigated wheat but there appears more potential for the summer crop pigeon pea to be sown on a larger scale in preparation for a following cotton crop.

4. Genetics for Heat Tolerance

Recommendations include irrigation scheduling trials to review plant resilience in hot regions, variety response to varying irrigation schedules and the effects during critical growth stages, and genetics for heat tolerance (variety trials).

These comments supported our observations that Walgett farmers are at the mercy of a hotter environment and less water security therefore find it harder to capitalise on the yield potential of more 'sensitive' Bollgard varieties. Properties west of Walgett do not have the security to supply water and/or have increased evaporation losses from storage and risk yield loss (if seven day irrigation cycles are not carefully planned for).

An irrigated variety trial in this area should be considered by breeders.

Two other issues have been raised in addition to information gathered in the above process:

- Defoliation/Pix® - the use of Pix® varies in western areas depending on moisture availability and climate – it is not normally a major issue to manage plant growth. However, in 2013 it was difficult to defoliate the new generation of compact plant varieties. Lower plant growth was protected and aerial spraying did not effectively penetrate foliage. Short-term on-farm research into the use of a ground rig utilising high water volumes is required.
- CGA believes it will be beneficial to invest in an additional weather station west of Walgett (lower floodplain) to support the availability of weather information for IrriGATEWAY. Currently there is one weather station 10 km east of Walgett. There is also uncertainty regarding the long-term future of the CSIRO IrriGATEWAY website (http://weather.irrigateway.net/aws/index.php) that has proven a valuable research tool for many involved in the cotton industry.

Investment Opportunities

There is an investment opportunity for a CRDC nitrogen efficiency project (Action on the Ground grants). It could include an extension agronomist working with key farming system scientists at the ACRI, Narrabri, for example from NSW DPI and/or CSIRO, undertaking trials at satellite sites.

Current CSD sites could be value added by combining nutrition trials, as prioritised in this project, and equipment made available to record day degree data and plant growth observations.

There are partnership opportunities for better functioning of RDE resources. NSW DPI has considerable expertise in irrigation technologies and a comprehensive knowledge and understanding of northern irrigated farming systems.

Investment into measuring water storage capacity on western properties, particularly when dry, is also recommended.

Appendix 1 – Results from WaterTrack Rapid™

Table 2 Results from WaterTrack Rapid™.

Farm name	Area (ha)	Crop yield (bales/ha)	Total water supplied (irrigation water) (ML/ha)	Total rainfall (ML/ha)	Effective rainfall (ML/ha)	Change in soil moisture (negative means an increase)	Total available water (irrigation + rainfall + soil) (ML/ha)	Crop water use (ML/ha)	Total available water losses (ML/ha)	Total supplied water use index (IWUI) (b/ML)	Gross production water use index (GPWUI) (b/ML)	Crop water use index
Nithsdale	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
Baroneal	61.00	13.57	9.31	1.71	1.41	-0.80	9.92	9.37	0.50	1.46	1.37	1.45
Walma	242.00	11.24	10.77	1.71	1.38	-0.81	11.34	9.11	2.20	1.04	0.99	1.23
Kalamos	142.23	12.13	10.27	1.68	1.39	-0.35	11.31	8.07	3.20	1.18	1.07	1.50
Milrea	142.00	8.48	8.44	1.68	1.40	-0.70	9.14	7.57	1.60	1.00	0.93	1.12
Carlton	319.00	13.10	11.09	1.21	0.99	-0.30	11.78	8.75	3.00	1.18	1.11	1.08
Walma2	227.00	13.74	9.33	1.71	1.41	-0.80	9.93	9.25	0.70	1.47	1.38	1.48
Average	**188.87**	**12.04**	**9.87**	**1.62**	**1.33**	**-0.63**	**10.57**	**8.69**	**1.87**	**1.22**	**1.14**	**1.31**
Minimum	**61.00**	**8.48**	**8.44**	**1.21**	**0.99**	**-0.81**	**9.14**	**7.57**	**0.50**	**1.00**	**0.93**	**1.08**
Maximum	**319.00**	**13.74**	**11.09**	**1.71**	**1.41**	**-0.30**	**11.78**	**9.37**	**3.20**	**1.47**	**1.38**	**1.50**

Appendix 2 – Management of a Dry Storage

Did you know when you first fill your storage after it's been dry, you can lose in excess of 2 ½ ML/ha of storage floor? The key recommendation from the IAA is to manage your storage the same way as you would manage a dryland field. You want to conserve moisture and reduce cracking. Therefore, weed control is important. In fact, you don't want any plant growth. Growing a crop in your storage can cause significant drying and cracking in both the embankment and the floor and subsequent loss of valuable irrigation water. If the storage soil surface is allowed to dry and crack, soil evaporation losses increase and significant amounts of water can be lost as it runs down the cracks and the dry soil soaks up the water.

While your storage is dry it is a good time to survey it and obtain an accurate depth-to-volume and surface area relationship. Often, the storage was not accurately built to the 'design' and actual volumes can differ by up to 20%. Over time, with a build up of silt and slumping of dam walls, the dimensions of your storage will change as well. Ideally a storage survey should be re-done after any remedial construction work on the banks or any other changes to the floor or borrow areas. It is worth considering doing an EM survey at the same time to differentiate soil types within the storage.

While your storage is dry your local surveyor can easily survey your storage. If you have access to GPS/Beeline you can survey your storage yourself and send the data into your local surveyor or engineering consultant for processing. To do this, drive in at least two pegs at ground level located near an inlet/outlet point as reference points or benchmarks. It is necessary to drive back over these points several times during the survey to establish a good level as a permanent reference height.

It is also an ideal time to install a gauge board or, for greater accuracy, you could set up a permanent storage meter. One that is readily available is the Irrimate™ Storage Meter that consists of a pressure sensor with an accuracy of ±10 mm. It is easy to install and continuously measures and records storage volume and water surface area. Knowing exactly how much water you have gives you the ability to fine tune its use and assist with water budgets. Storage meters can also be used to get an accurate measurement of the amount of tail water and storm water you recover and can be used to check pump capacity when pumping directly into your storage.

Following significant rain in the catchment, care needs to be taken when filling a storage that has been dry for some time. To avoid potential problems such as erosion and blow outs, dry storages should be filled slowly. If possible, the filling rate should be no more than 300 mm of water per day, and preferably less than 100 mm a day.

Appendix 3 – Letter to Participants

Australian Government
Cotton Research and Development Corporation

25th February 2013

Dear Participant,

RE: CRDC project "Moving in and out of Cotton —Identifying Farming Systems Issues in WESTERN NSW Irrigation Areas".

The progress of plant growth when compared to accumulated day degrees modelled by CottASSIST Table 1(http://cottassist.cottoncrc.org.au/) indicate that crops remain on average 150 to 200 day degrees higher. However, the Emergence, 1st square, 1st Flower and 1st Open Boll dates fall between the min. and max. Dates modelled by CottASSIST as shown in Table 1. We have attached the graphs again of each field for comparison Figures 1 to 5. The graphs also contain the average nodes per plant and average plant heights during the same period. The crops are cutting out now shown by the levelling out of the curves in Figures 1 to 5. Figures 6 and 7 highlight the difference in accumulated day degrees between Narrabri and Walgett. The Walgett cotton has experienced an additional 183 DD when compared to the Narrabri region (Figure 7).

A field day is planned for the 6th March and John and I would like to gather some information in regard to research issues that are a priority in the Walgett region. As this is a scoping project we will need to complete a full project proposal to submit to the CRDC. Some of the issues that may be of interest in the full project could research nutrition (N, P and K), irrigation scheduling (i.e. effects of pushing cotton when short of water) and back-to-back cotton (impact on crop development, nutrition and yield).

If you have further ideas for research please let me know, there will be an opportunity to discuss research ideas on the 6th March and contribute further.

We are also intending to collect the irrigation data the day after the field day on the 7th March. If you are available to meet with us and have a preferred time that would suit please let me know via email or contact me on 0409 069 277.

Thank you

Kind regards, Tim Weaver & John Sykes

Table 3 Estimated stages of cotton growth and accumulated day degrees using Walgett Airport data for comparison with on-farm crops.

Source: CottASSIST.

Target	Day Degree	Actual	Minimum	Maximum	Average	Median
Emergence	106	26 Oct	22 Oct	2 Nov	28 Oct	28 Oct
First square	562.2	30 Nov	23 Nov	15 Dec	4 Dec	3 Dec
First flower	834.2	17 Dec	11 Dec	8 Jan	23 Dec	23 Dec
Open boll	1584.2	-	28 Jan	28 Feb	9 Feb	11 Feb

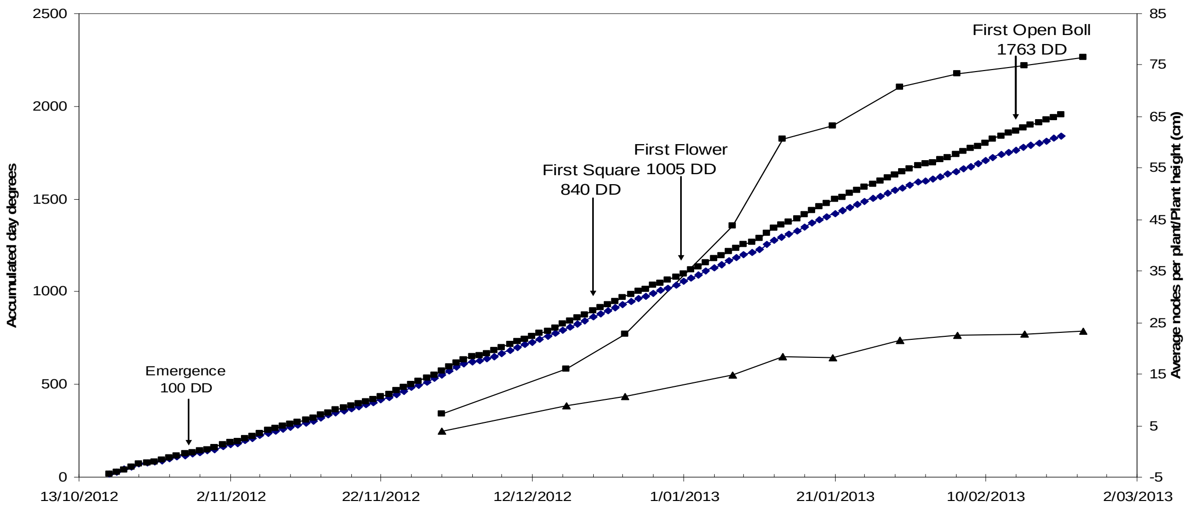

Figure 1 Average nodes per plant and average plant height at 'Walma'.

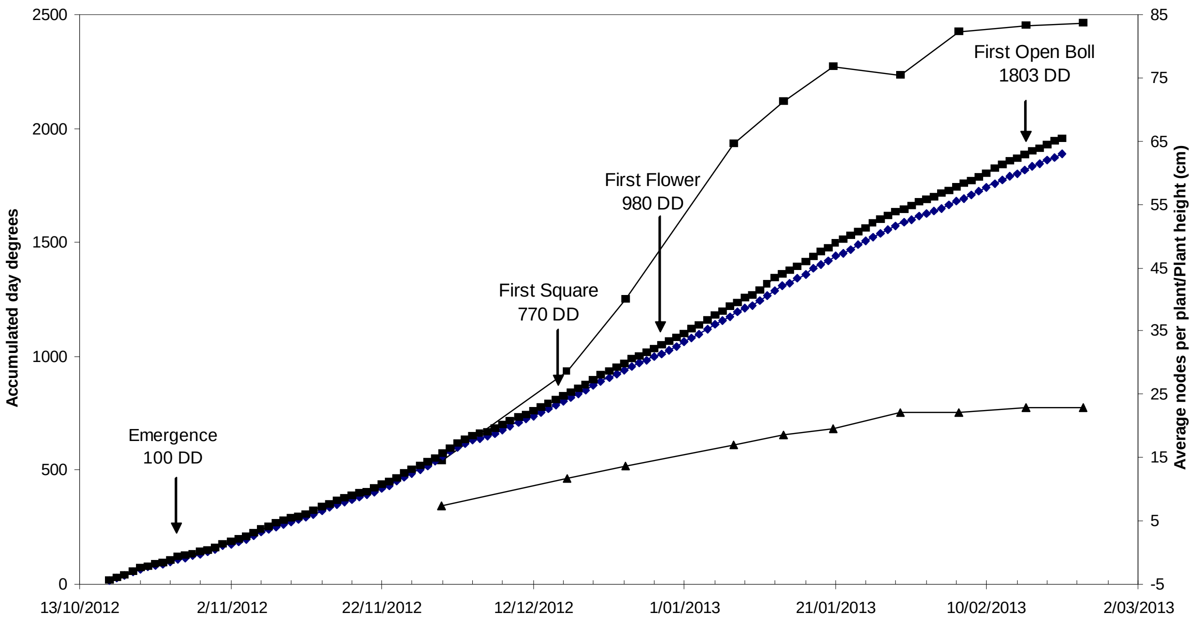

Figure 2 Average nodes per plant and average plant height at 'Baroneal'.

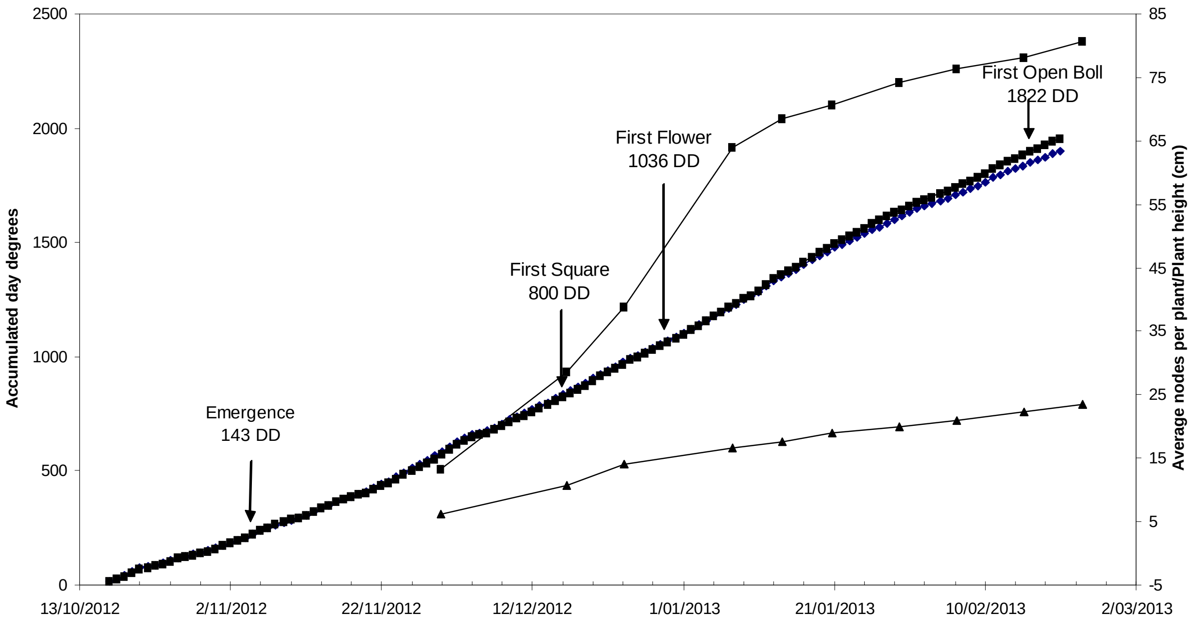

Figure 3 Average nodes per plant and average plant height at 'Kalamos'.

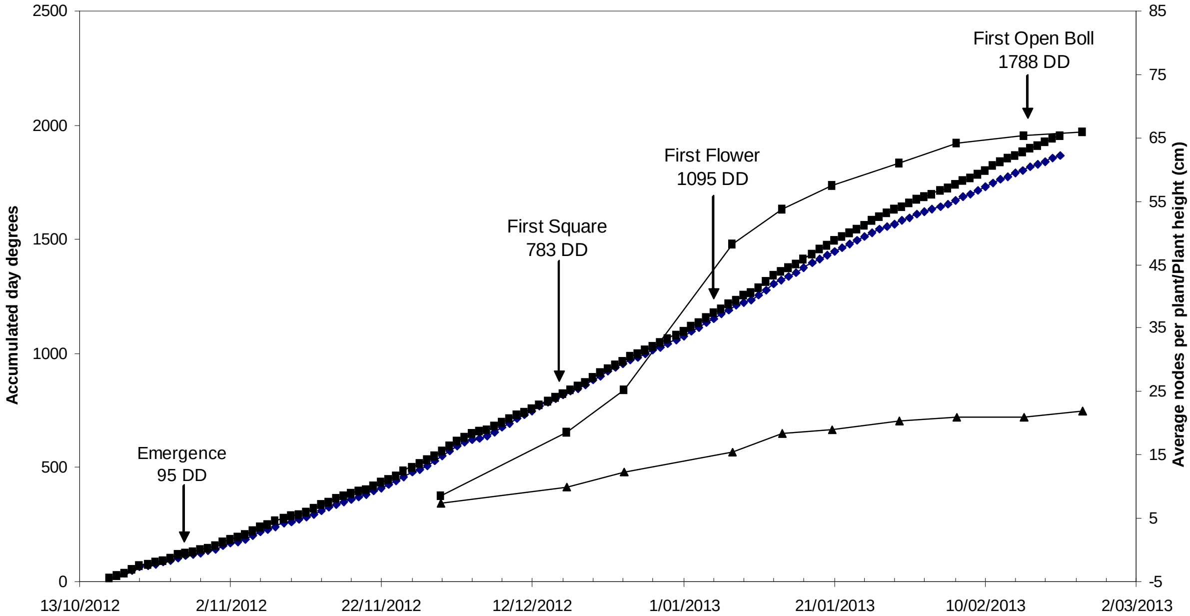

Figure 4 Average nodes per plant and average plant height at 'Nithsdale'.

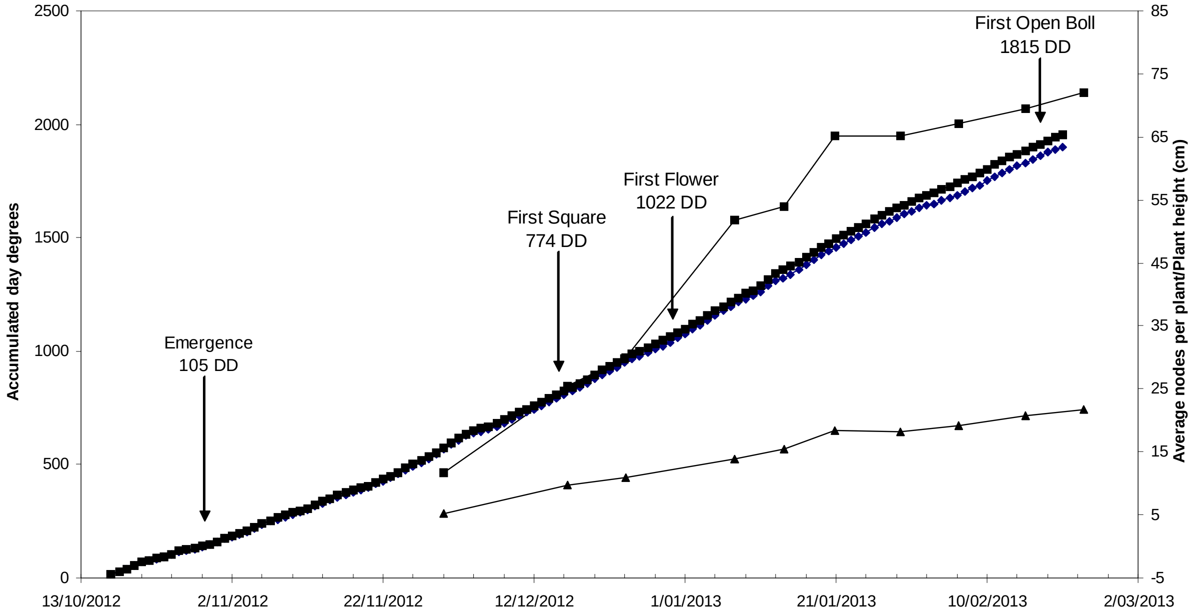

Figure 5 Average nodes per plant and average plant height at 'Milrea'.

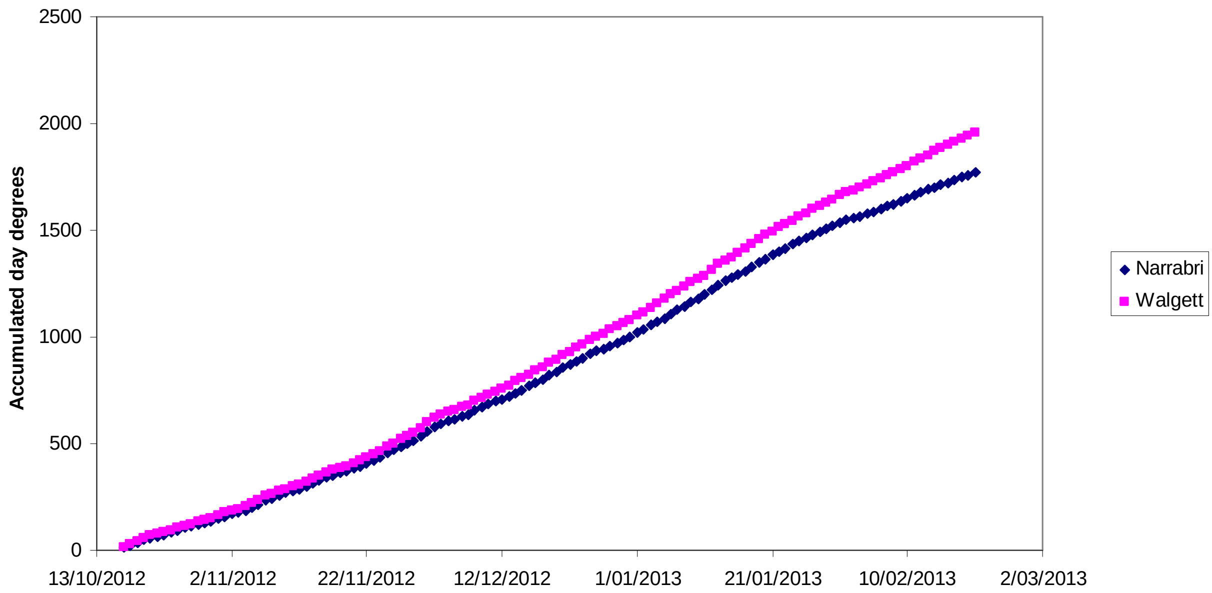

Figure 6 A comparison of accumulated day degrees at Narrabri and Walgett.

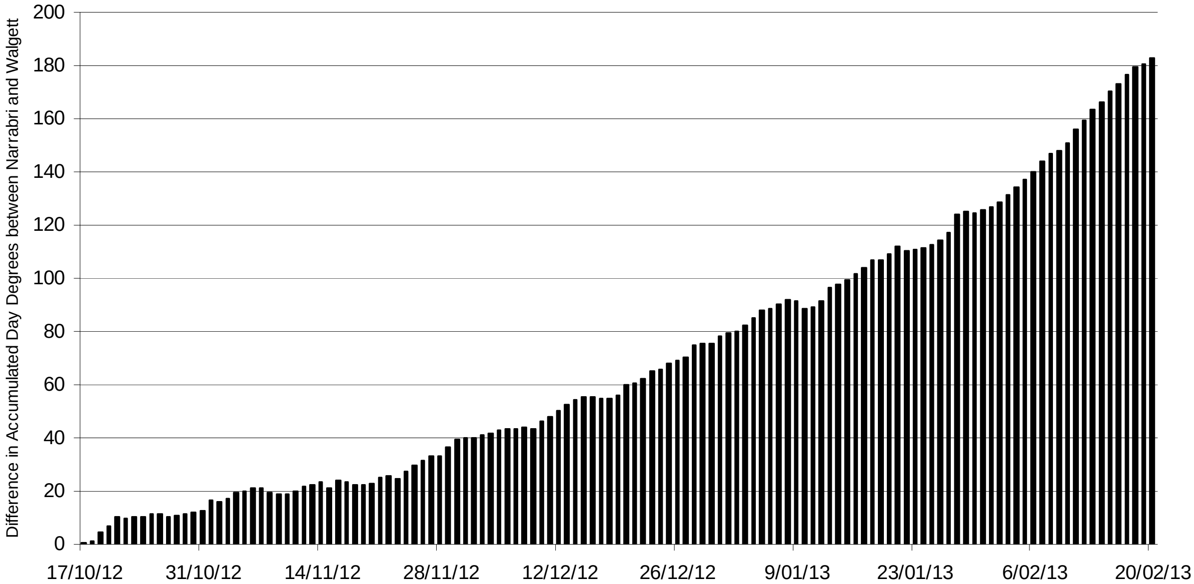

Figure 7 Difference in Accumulated Day Degrees between Walgett and Narrabri. On 20 February Walgett was 183 DD ahead of Narrabri's accumulated day degrees.