COOPERATIVE RESEARCH CENTRE
FOR SUSTAINABLE RICE PRODUCTION

ANNUAL REPORT 2004/2005

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Australian Government’s Cooperative Research Centres Program

PART C
A brief snapshot of achievements within Program 4 during the life of the Rice CRC

A unique feature of the rice industry in Australia is its level of vertical integration and the importance of the processing sector in creating value for the communities. Program 4 was successful in creating new opportunities at many levels of the processing (post farm gate) sector. Highlights included:

- Development of an improved receival system that better met industry requirements in measurement of trash, moisture and allowed some analysis of grain quality for specific markets.
- Development of some in-line processing control systems to control milling quality and analyse product quality.
- Development of improved drying procedures to minimise the cost of drying while maximising quality of the dried rice.
- Development of improved quality assurance procedures across the processing sector.
- Development of improved pest control techniques, particularly for replacements for methyl bromide.
- Development of improved mineral enrichment techniques.
- Improved understanding of the properties of rice flour from different cultivars.
- Development of new quick cooking and retort rice products.
The final year of the CRC has seen much of the Program 4 research work, including that from earlier years, reach maturity in its application by industry or enter into commercialisation. Aspects of technology developed with CRC research such as grain drying techniques now sit as standard practice in the industry, with SunRice recognised as a renowned leader in this aspect of grains handling. New consumer products such as retort pouch rice, which commenced with research at the beginning of the CRC, has now been fully commercialised with the support of ongoing research through the development process to deliver a product that has gained international attention for its unique quality.

In addition to helping deliver better products and processes in the industry today, the CRC has created a much further reaching legacy. This includes increased insight into rice science and technology, education of a pool of talent, creation of new research relationships, development of a more sustainable production system and a greater awareness of the role and benefit of science and technology. These benefits are now placed for future application and development.

4.1 Grain quality in the pre-milling phase (*4101*)

Objective

To monitor and improve quality before milling and to assure the quality of rice delivered to the industry.

This project has been the subject of many sub-projects over the life of the CRC. The following are the sub-projects which were active during 2004/2005.

* Adaptive Discounting Control in Paddy Storages

The trial is a demonstration of the performance of the “Adaptive Discounting” aeration control method (ADC) for drying paddy rice within Ricegrowers’ Co-operative Limited (RCL t/as “SunRice”) facilities. This control method has been developed at CSIRO Stored Grains Research Laboratory (SGRL) over the last three years for a broad range of aeration applications; drying, cooling and maintenance. It has been successfully trialled for aeration-
drying applications previously using aerated transportable farm silos and the crops sorghum and canola.

The general experience with aeration drying systems (or in store drying) is that the grain is over-dried near the aeration air inlets and insufficiently dried or “marginal” near the air outlets and peripheral zones. In the RCL situation, this results in paddy being supplied to the mills with varying moisture contents and an increased susceptibility to breakage. The aeration control method developed at SGRL can address this limitation.

The new control method also provides a range of more universally applicable benefits. The key benefits are as follows:-

* a “user friendly” operator interface;
* maximum thermodynamic efficiency regardless of aeration system size and weather conditions;
* capacity to input target grain moisture contents (and temperatures); and
* controller automatically turns aeration process down as the target is achieved.

**Objective**

To measure the capacity of the adaptive discounting method to dry paddy rice to a target moisture content within RCL aeration bin without a significant moisture profile across the depth of the bin. This extends to evaluating its effectiveness in different shed types and at different geographical locations.

**Progress**

Past trials have shown the influence of high moisture on defects in grain quality. The results show that the ADC trial better controls the aeration of a bin. This is because the controller is able to determine external environmental conditions over a 24 hour period and immediately make suitable changes to the amount of air being pushed through the grain mass. This ensures that on occasions where external conditions are not favourable (eg - rain), moist air is not pushed through the grain mass.

**Future work**

The trial has been ongoing since 2001. Proving both successful and promising, SunRice and CSIRO have negotiated further arrangements for its application to other storage facilities. Depending on the age of some structures, various functioning equipment (eg - aeration fans, fan control equipment, aeration introduction systems) are quite different and in some cases not as favourable as those at Shed 4 Gogeldrie (used to conduct this trial). This has moved the studies to show its adaptability in older, less advanced sheds to give an understanding of how broadly this system may be adopted. SunRice is also interested in the implications of geographical location and different climates and how ADC will behave.
Determination and implementation of a standard paddy aeration strategy across the paddy group, to enable effective drying and aeration of crop, without compromising paddy milling quality

SunRice had determined the need for a standard aeration strategy. In the past, various aeration strategies have been adopted at paddy sites resulting in a non-uniform standard operating procedure and consequent uneven quality distribution.

In 2003, SunRice decided to adopt, train and implement the “Six Sigma” methodology into the business. Six sigma aims to improve:

* quality of product and process;
* customer service;
* cost of business; and
* profitability
by:
* setting clear business and functional objectives;
* articulating and defining critically analysed strategies;
* setting up framework for clear communication; and
* successful execution of action plans.

Aeration was seen as an area requiring improvement, and subsequently was identified to be a “Six-Sigma” pilot project in 2003.

Objectives

To develop and implement a standardised aeration strategy across the paddy group, utilising best available practice procedures, with the aim of ensuring paddy moisture and quality meet customer requirements.

Progress

Determination of current status

* Audit of sites were conducted to determine the current operating procedures, operating system within sheds, structure type, fan sizes, moisture probe procedure used, method of data collection and retention, whether temperature probing was performed and who was responsible for signing off on changes. SunRice expected to improve quality standards of rice supplied to mills and reduce loss due to downgrade and shrinkage costs.

* Canvassing other technology in moisture/temperature analysis and heat imaging through research.

Determination of milling results

* For a twelve month period, data from both Leeton and Deniliquin mills were analysed and collated to determine the paddy moisture as delivered to mill, finished product moisture and heat damage (stackburn) for each bin supplying to the mill.


Determination of new aeration operating procedures

* Through analysis of the above information and combining the learnings and practices of the “SunRice Supervised Bin” (Shed 4, Bin 5, Gogeldrie) from the Adaptive Discounting trial, determine a set of standard operating procedures, documentation and data recording facilities necessary to ensure uniformity of operation across the industry combining a “best practice” system.

* Determine temperature evaluation requirements within the aeration procedure and source availability of such products.

Outcomes

Determination of current status

* No site had a set operating procedure, some of which was based on operator experience and trial and error.

* Documentation was rarely retained, therefore making it impossible to determine any links between the data and quality levels found at mill level.

Determination of milling results

Table 1: Breakdown of mill data

<table>
<thead>
<tr>
<th></th>
<th>Deniliquin</th>
<th>Leeton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave Daily Heat Damage (%)</td>
<td>0.3</td>
<td>0.091</td>
</tr>
<tr>
<td>Ave Paddy Moisture (%)</td>
<td>12.4</td>
<td>11.9</td>
</tr>
<tr>
<td>Current Target (%)</td>
<td>12.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Paddy Variance (%)</td>
<td>0.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Ave FP Moisture (%)</td>
<td>13.3</td>
<td>12.9</td>
</tr>
<tr>
<td>Ave FP Milling Variance</td>
<td>0.9</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 2: Average results of combined data

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Weighted Paddy moisture to mill average</td>
<td>12.25%</td>
</tr>
<tr>
<td>Minimum Paddy moisture target</td>
<td>12.50%</td>
</tr>
<tr>
<td>Improvement Target</td>
<td>0.25%</td>
</tr>
</tbody>
</table>

Table 2 shows a moisture target of 12.5% set for crop year 2004. This is a 0.25% improvement target on the previous year’s average. This is expected to produce savings in excess of $360,000 through energy savings and yield efficiency.

Determination of new aeration operating procedures

* From the results of the audit and results of the mill analysis it was clear that a defined direction was needed for aeration activities.

* A set of standard operating procedures combining recording of data manually and electronically were developed through combining the knowledge and learnings of our experienced operators.
A reporting procedure was defined to ensure the continual development and improvement of aeration activities by way of internal complaints process.

This procedure was encompassed in the “Paddy Operations Aeration Manual”.

Achievements

* The new system allows SunRice to further define the requirements for aeration which will continue through analysis of the data now available.

* Major improvements in the quality of paddy whilst in storage through a standard procedure streamlining this process. A storage moisture target has been set to optimise cost benefit.

* It was identified that temperature measurement would assist in determining areas known as “hot-spots”. During the 2005 harvest, different pieces of temperature measuring equipment will be trialled for adaptability.

* Regular data analysis ensures the aeration of paddy rice is scientifically controlled.

* From harvest 2004 and the introduction for the Aeration Manual, monthly audits have been introduced to ensure the manual was being followed and data recorded correctly.

* These previous outcomes ensure continuous improvement.

* **Image Analysis as quality measurement at point of receival**

Currently, SunRice employs casual staff at harvest to assist in the short-term increased responsibility at receival points. This means that operators are trained just prior to harvest. Many tests are required to determine the quality of a load as it is brought onto a receival site. Knowledge of the quality is important for segregating, varieties, varying moisture levels, defect loads (dockage) etc.

The process of such testing relies strongly on operator interpretation of visible contaminants. Other defects are not identified at this point as there can be great variation between operators and as a result no uniform segregation of grain.

Objective

To determine whether image analysis can replace operator determination of quality and allow a broader analysis of grain quality at point of receival. A 1625 Cervitec Grain Inspector® (on loan from FOSS®) was used for this study.

Progress

FOSS and SunRice have made many attempts at devising a strategy for use of this machine. It is necessary to perform such a study in stages and it was decided that initially a limited number of defects would be studied. Mill quality test samples of brown rice were taken and
any defect material removed for processing in the Cervitec. Due to reduced crop size (due to drought), only a limited number of samples have become available to date and these have not yet been sufficient to develop a calibration.

Samples will continue to be collected and the trial will continue.

*Analysis of the Infratec® as a replacement for the Grainspec® for moisture determination – Phase 2*

Previous trials had outlined that the Grainspec NIT grain analyser gave a much more accurate result when testing rice. New calibrations for rice have since been developed in Japan for the new upgraded Infratec.

**Objective**

To revisit and determine whether the Infratec machine is a suitable replacement for the Grainspec machine, to be used for moisture determination.

**Progress**

Samples of varying moisture (ranging 10-26%) are experienced during harvest receivals. The current process involves the checking and altering of calibrations of the Grainspec during harvest on a weekly basis. Data is gathered by scanning identical samples through the Grainspecs and Infratecs, then verified by laboratory moisture analysis. All harvest samples were scanned through the Infratec. Calibration was developed with the assistance of FOSS.

**Outcomes**

**Figure 8:** Infratec result compared to Lab result for mill paddy
There is no real correlation between increasing moisture and increasing error. The Infratec is predicting results outside of the desirable ±0.5%; however most are within this range. This may result from a smaller moisture range and lower moisture levels in the grain.

**Figure 9:** Infratec result compared to Lab result for harvest paddy (dried)
There is no real correlation between increasing moisture and increasing error. The Infratec is predicting results outside of the desirable ±0.5%, however mainly lie within a 0% to 1.0% range; suggesting incorrect scaling in the calibration.
There is no real correlation between increasing moisture and increasing error. The Infratec is predicting results outside of the desirable ±0.5%, most of which are approximately -1.00% less. This may be due to incorrect scaling in the calibration of the Infratec and the outlier at >19% could be due to an insufficient calibration.

There is no real correlation between increasing moisture and increasing error. The Infratec is predicting results outside of the desirable ±0.5%, most of which are range from -0.5 to -0.9 differences. This may be due to incorrect scaling settings. The lower variation is probably due to a smaller moisture range and lower moisture levels in the grain range.

There is no real correlation between increasing moisture and increasing error. The Infratec is predicting results outside of the desirable ±0.5%. Most lie within -0.5% to -1.5% range; which once again may be due to incorrect scaling in the calibration.

There is no real correlation between increasing moisture and increasing error. The Infratec is predicting most results inside of the desirable ±0.5%. This is probably due to a smaller moisture range and lower moisture levels in the grain.

In most cases a smaller moisture range allows the Infratec to predict more accurately, and with larger moisture ranges it predicts much less accurately.

There also seems to be a common scaling issue where results are somewhat consistent but out of range. The calibration is not yet strong enough.

The number of samples processed was largely minimised by a lower crop size resulting in less available samples.

Results were sent to FOSS for analysis and they have developed the calibration further. Further trials will be conducted in the same manner using the 2005 harvest rice.
* Consolidation of all hygiene activities into a standard operating procedure

Objective

To Test suitability of azamethiphos (as Alfacron®, from Novatis) as a suitable structural treatment for paddy receival sites and develop improved hygiene protocols.

Progress

* Review recommendations from prior hygiene related trials and develop work procedures.

* Review trials of Alfacron® as a structural treatment.

* Trial and identify any residues left in rice at one week, one month, two months and three months in bins treated with Alfacron® for structural treatment.

This work was placed on hold due to discontinuation of Alfacron® production.

4.3 Quality assurance systems and post-harvest pest management

Sub-Program Leader:
Mr Tim Norris
SunRice
Leeton

The Australian rice industry must be leaders in the field of quality assurance and food safety. This extends from farmers’ fields into the processing sector.

Sustainable fumigation practices (4303)

Project Leader:
Ms Bronwyn Sigmund
SunRice
Leeton

Objectives

To develop pest control practices which are less reliant on methyl bromide.

This project has been the subject of many sub-projects over the life of the CRC. The following sub-projects were active during 2004/2005.

* Phosphine Fumigation of Paddy Rice, Shed 10, Emery

SunRice has erected two sealed storages on both Deniliquin and Emery sites. These storages are both 12 sided and of 20,000 tonnes capacity.
Due to the limitations of harvesting rice between February and June and using this over a 12-18 month period, quality of grain can be difficult to maintain. The intention of such storages is to hold grain for extended periods under fumigation to ensure quality is maintained and improved through limiting or ceasing insect damage and associated quality reduction such as stackburn.

This trial was conducted by Dr Joanne Holloway and Kathryn Smith (NSW DPI, Wagga Wagga).

**Figure 14**: 12-sided shed at Emery site.

**Figure 15**: Shed 10 – Emery filled with 7000 tonnes of paddy rice.

**Figure 16**: (from L to R) Steve Hussey (SunRice), Darren Poole (SunRice) and William Shore (GasApps) sealing door and setting up phosphine introduction equipment.

**Figure 17**: William Shore (GasApps Australia) and Darren Poole (SunRice) measuring gas concentrations.

**Figure 18**: Dr Jo Holloway and Kathryn Smith (NSW DPI) inserting bioassays into grain bulk.
Progress

The Roundhouse at Emery, a 12-sided shed of 20,000 tonnes capacity, was surveyed prior to filling with last season’s paddy rice. Evidence of rice weevil (*Sitophilus oryzae*) and lesser grain borer (*Rhyzopertha dominica*) were found in some old grain that had not yet been cleared away. SunRice followed their normal procedure of cleaning out and spraying the shed with a surface protectant treatment prior to inloading the paddy rice.

A bulk of 7,000 tonnes was inloaded, with each load of paddy rice sieved to check for any natural infestation of insects, but none were found. A phosphine concentration of 100 ppm for at least 20 days was recommended to ensure a successful fumigation. To allow for sorption of the gas into the rice and any losses due to small leakages within the shed, approximately double the required concentration of phosphine was pumped into the shed.

Due to a leak in the shed there was a drop in phosphine concentration during the fumigation period, and the shed had to be re-gassed 15 days into the fumigation.

*Phosphine monitoring*

Prior to the inloading of paddy rice, 12 lines for monitoring phosphine fumigation were set up and another 22 were set-up inside the bulk. A further 16 original monitoring valves were located at regular intervals in the wall of the shed for monitoring gas concentrations around the perimeter.

For the first 24 hours after gas filling was completed, staff monitored phosphine concentrations through the tubes every two hours. In addition, six hourly concentration readings were also taken from the 16 perimeter monitoring points. Thereafter, staff monitored concentrations once a day from their 38 monitoring points (22 through the bulk and 16 around the edge of the shed).

*Insect bioassays*

One weak and one strong resistant strain of lesser grain borer, *Rhyzopertha dominica* (SR Rd; WR Rd), and a strong resistant strain of rice weevil, *Sitophilus oryzae* (SR So), were set up to provide 21 cultures (6 experimental and 1 control for each strain) containing all stages (eggs, larvae, pupae and adults) of the insects. For each culture, either 100 adult *R. dominica* or 50 adult *S. oryzae* were placed in 100 g of moisturised grain and maintained at 25 °C and 60 % rh.

Prior to the fumigation, the experimental cultures were transferred to insect-proof assay probes and positioned in the bulk. A further series of eight assay probes were placed around the circumference of the bulk.

In addition to the assay probes, two temperature dataloggers were also placed within the paddy rice bulk. These were located next to the SR Rd at 6 m (location 4) and the WR Rd also a 6 m but on the opposite side of the bulk (location 14). These were also retrieved after the shed was vented and all information downloaded. Unfortunately, due to battery failure, no information could be retrieved from these loggers and consequently no temperature data were obtained for this trial.
Outcomes

Phosphine concentrations

Concentrations of phosphine within the bulk reached between 200-250 ppm 2-3 days after gas filling (Fig. 19). Phosphine concentrations then steadily declined until day 15, when concentrations at all monitoring points dropped below 100 ppm. This was when a leak was discovered and repaired. At this time gas concentrations within the bulk were between 70-85 ppm. The shed was then topped up with approx. 100 ppm of phosphine in order for the bulk to achieve the recommended concentration of at least 100 ppm for 20 days. Phosphine concentrations again declined and were between 70-100 ppm when the shed was vented 24 days after the fumigation commenced. While the phosphine penetrated throughout the bulk, concentrations were generally lower at the base.

A “successful” fumigation is a cumulative CT product (concentration x time) of 100 g.h/m³. This was achieved prior to the shed being vented at all except two of the monitoring points. Both of these points were located at the base and close to the centre of the bulk. Of the other monitoring points, the cumulative CT product of 100 g.h/m³ was not reached until day 22 of the fumigation at five locations.

Figure 19: Phosphine concentrations at 13 monitoring points located throughout a 7,000 t bulk of paddy rice during a trial fumigation at the Roundhouse, Emery
Figure 20: Cumulative CT product of phosphine at 13 monitoring points located throughout a 7,000 t bulk of paddy rice during a trial fumigation at the Roundhouse, Emery

**Insect bioassays**

Once retrieved, the probes were taken back to the laboratory, the grain sieved and adult insects counted. No live insects of any of the three strains were found at this stage. The grain was then incubated for eight weeks to see if any eggs or pupae survived the fumigation and developed into adults. No rice weevil, *S. oryzae*, emerged from these cultures and, therefore, the fumigation was successful in controlling this species.

However, the lesser grain borer, *R. dominica*, was not completely controlled, with adults emerging from the grain cultures in both the weak and strong resistant strains. Perhaps surprisingly, eggs and/or pupae survived in four of the six probes containing the weak resistant strain, compared with only one of the six probes with the strong resistant strain. This anomaly may be explained by a number of reasons, including mislabelling the strains, but was probably due to the lack of robustness of the strong resistant strain. Despite this, the fact that some *R. dominica* (both strong and weak resistant) survived indicates that the concentration of phosphine was not held at a high enough concentration for a long enough period in order to kill all life stages, and that the fumigation failed to control this species.

While some locations within the paddy rice bulk achieved the recommended phosphine concentration of 100 ppm for 20 days, a number of points failed to attain this dose. Consequently, eggs and/or pupae of resistant *R. dominica* strains survived within the bioassay probes and the fumigation can be deemed to have failed.

In conclusion, the fumigation failed because the phosphine concentration was not held high enough for a long enough period of time. The primary reason for this appears to be leaks within the shed. It is unknown to what extent sorption by paddy rice and aeration may have contributed to the failure, if at all, as the leakage would probably have masked their effects.

*Note:* This trial is expected to be repeated in March/April 2006 pending availability of paddy rice.
Treatment of rice products with ethyl formate

Due to the phase out of methyl bromide under the auspices of the Montreal Protocol, alternative treatments are being sought for many commodities that have traditionally been fumigated with that gas. Ethyl formate is a fast acting fumigant which can kill all stages of many insects within hours, which makes it an attractive alternative to methyl bromide.

Ethyl formate can be highly sorptive and the concentration of gaseous ethyl formate may fall rapidly when placed in contact with a commodity, to levels that are not lethal to insects (Reuss and Annis, 2003). If this fumigant can be distributed through a commodity quickly and a lethal concentration maintained for sufficient time, it promises to be a fast and effective fumigant. One method to ensure distribution is to apply the liquid ethyl formate to small units such as bags of finished product, as is currently done in the dried fruit industry.

Objective

To determine whether ethyl formate is a suitable replacement for methyl bromide.

Progress

In this preliminary study an application rate of 100 mg/kg ethyl formate was assessed for in-bag disinfection of processed rice. This included bioassays on insects representative of those that may be found infesting rice and points to some of the occupational health and safety issues that may arise from this application method.

Outcomes

Permeability

* Nylon film (750g packaging) is not permeable to ethyl formate.

* Film used in the 2kg packages was permeable to ethyl formate. This level of permeability may pose an occupational risk if “in bag” fumigation is pursued.

* However, it also indicates that external application of ethyl formate as a standard fumigation may be viable.

Bioassays

* In the bioassay trials of mixed age cultures of S. oryzae exposed to a dose of 100 mg/kg for 7 days, 100% mortality of adults and larvae was observed. 100% mortality of eggs was observed in the 750 g packages and reduced mortality for eggs in the 2 kg packages (97.9%) and 500 g packages (57.1%). There were insufficient pupae to assess the mortality.
* Increasing the applied dose from 100 mg/kg to 200 mg/kg is likely to improve the mortality observed in both the 500 g and 2 kg packages.

Outcomes

* Increasing the applied dose would also increase the concentration of ethyl formate in the vicinity of the packaging line and in storage area and would need to be further assessed for the possibility of exceeding the flammability limit and exceeding the safe working concentration of this gas.

* On most packaging lines at SunRice an injection of liquid ethyl formate could be done during the filling process. On some of the packaging lines, suction plates are used to pick up and place the bags into boxes. This packaging procedure would be incompatible with the use of ethyl formate in this manner because the vacuum created would forcibly withdraw the gas from the bags before fumigation was complete. Ideally bags fumigated by injection would not be pin wheeled as the holes created in this process are an obvious point for gas loss and possible reinestation. However, as these studies have shown, fumigation “in bag” of larger bags that are pin wheeled may still achieve a fumigation profile that will control most insect pests.

* Quality assessment was not performed and would need to be done in any subsequent trials of this nature.

Trials in this application to consumer packs is being explored early-mid 2005 and thus far is the most promising replacement for methyl bromide studied.

* **Assessment of a lowered dosage of methyl bromide for finished product fumigation**

In its evaluation of an application for a critical use exemption for methyl bromide as a fumigant of consumer packs of rice in Australia, the Methyl Bromide Technical Options Committee (MBTOC) accepted that there was currently no viable alternative treatment but reduced the quantity of methyl bromide available for this use by half (from 12.3 to 6.15 tonnes). MBTOC also suggested that the dose used be reduced to a rate of 24 g/m³ for 24 hours in the absence of any particular circumstances that might justify a higher rate.

The Australian label rate for general fumigation of cereal products with methyl bromide to control stored product pests is 24-32 g/m³ for 24 hours at atmospheric pressure and temperatures above 15°C. This is higher than the rate recommended by the European and Mediterranean Plant Protection Organisation (EPPO) for phytosanitary treatment of rice (15 g/m³ for 24 hours at temperatures between 10-20°C, but lower than that recommended for quarantine treatments by the Australian Quarantine and Inspection Service (40 g m⁻³ for 24 hours at 15°C and atmospheric pressure).

Objective

To assess a lowered dosage of methyl bromide for finished product fumigation.
Progress

* Two stacks of the same size, commodity and construction were fumigated on site inside a large warehouse at the SunRice facility at Leeton. Each stack consisted of four rows of pallets, three pallets high and fourteen pallets deep.

* Each stack was monitored for gas concentration at six locations. Gas sampling lines (1/4 inch and 1/8th inch nylon tubing) were run from locations in the stack to outside the 6 m exclusion area set up around each stack in accordance with the Australian Fumigation Standard.

* Five locations were the same in each stack; three sampling lines were inserted between the pallets in the top layer of pallets and two between pallets in the bottom layer of pallets. In stack 1, the sixth sample line was inserted into a box containing the rice packages in the centre of the bottom layer of pallets. In stack 2, the sixth sample line was inserted into a bag of rice inside a box in the centre of the bottom layer of pallets.

Outcomes

* The only adult insects observed emerging from bio-assays were *Plodia interpunctella*. In other sections of the stack, the CT product was measured at higher concentrations sufficient to kill eggs of pyralid moths, however eggs were found to survive at a number of locations throughout the stack.

* In this trial, only one line was inserted into bags of rice to observe the concentration of gas within the rice (where any insect infestation would be). To confirm that the concentration of gas inside the packages of rice are this low, a similar trial should be undertaken where multiple lines are inserted into bags of rice so that the low concentration observed in this trial can be confirmed.

This trial is being repeated in April 2005 ensuring monitoring of gas concentrations and placing of bioassays occurs inside packs.

* **Assessment of a lowered dosage of methyl bromide for finished product fumigation**

Information has suggested that packaging is creating a major barrier between fumigant and rice intended for fumigation. This risks unsuccessful fumigation if not properly understood. With the phase out of methyl bromide and the suggestions from the MeBr committees to halve usage of methyl bromide, it may be that the dosage is not enough to perform a successful fumigation.

Objective

To assess products and their permeability to fumigant.
Progress

Over 50 trials have been conducted on all pack sizes at different dosage rates of methyl bromide in normal fumigation facilities. These have been set-up during normal fumigation operations and have included monitoring of gas concentration inside packs. Information gathered thus far indicates that some pack sizes are not as permeable to gas as is required with some dosage rates.

These trials will be ongoing, however results are indicating that packaging permeability needs further study.

Quality assurance for the processing sector (4306)/Development of rice milling in-line process control (4201)

Project Leader: Mr Tim Norris
Project Engineer: Mr Owen Hennicke
SunRice
Leeton

Objectives

To implement quality assurance systems and a best practice continuous improvement process across all levels of the processing sector with initial focus on the following:-

* reduce whole grain rice losses to the various waste streams from rice milling;

* particular focus on losses via the hull removal system at both Leeton and Deniliquin mills; and

* incorporation of Six-Sigma process improvement methodology.

Outcomes

This project worked on the two main branches of Continuous Improvement Systems (Six Sigma) and Process Control Systems enhancement. During 2004-2005 the SunRice Six Sigma process improvement system was developed and implemented. It is a process improvement methodology that can apply across the entire business; it is a methodology that is systematic, effective, fact based and process oriented. Considerable effort has been invested in training people in the methods of Six Sigma and several pilot projects were successfully implemented with significant savings.

Process Control Systems enhancement has focused on the installation of an on-line Process Weighing system in Leeton Mill and an integrated web-based reporting system.
4.5 New rice-based foods

Sub-Program Leader:
Mr Phillip Williams
SunRice
Leeton

This Sub-Program is evaluating new technologies that will promote the development of new rice-based food products.

New rice-based food products (4501)

Project Leader:
Mr Phillip Williams
SunRice
Leeton

Objectives

* Develop novel processes for flavouring of rice cakes.
* Develop an objective method for assessment of texture in rice cakes. This research will continue using an existing electronic texture analyser.
* Investigate objective aroma assessment of rice and puffed rice. This research will be undertaken in collaboration with CSU and the CSU Znose for electronic detection of aroma and subsequently aroma assessment.

* Rice Cakes

One major research project within Project 4501 has been studies on rice cake texture and attempts to develop an objective method to assess rice cake texture.

Progress

This work has confirmed the major impact rice cake moisture has on cake texture and correlations with taste panel results have provided data on the moisture content range over which consumers consider the texture to be declining in acceptability and also at which texture is no longer acceptable. Developing an objective method which has a good correlation with taste panel results has not yet been achieved.

The impact of processing conditions on rice cake texture and other quality attributes is also being assessed.
Outcomes

Rice cake moisture content is a key determinant of cake crispness and overall cake texture. Initial rice cake moisture content is related to the initial moisture content of the brown rice before puffing. Other processing conditions used to puff the brown rice also have an impact on final cake moisture content and other cake quality attributes.

Work on the development of an objective measurement of rice cake texture is continuing.

* Aroma assessment of rice and puffed rice

Rice undergoes both physical and chemical changes during storage. These can affect processing characteristics and consumer acceptance.

In previous CRC work (Zhou et al, 2003), it was demonstrated that fatty acid breakdown may be responsible for off-aromas. This work aimed to demonstrate methods for monitoring aroma development during storage and the influence of degree of milling on such development.

Progress

Several students at Charles Sturt University have been engaged by SunRice to carry out work related to this project, and a summary from a student presentation by A.G. Bishop is provided.

**The effect of milling degree on changes in aroma profiles of stored rice**
(F-X. Lauvray, M., C.L. Blanchard, A.G. Bishop, P. Williams, S. Helliwell and K. Robards)

A zNose™ was used to examine changes in volatile compounds in rice after nine months of storage at high temperature. The influence of degree of milling on these compounds was then examined.

Three large peaks in the zNose profile were detected in milled rice. Two decreased during storage and one increased with aging. This was thought to be related to the development of off-aromas during storage.

The change in aroma profile, after nine months of storage at 37°C, was reflected in the peak profile as measured by zNose. The profile of heavily milled rice was more affected than that of lightly milled rice. This supports the view that heavily milled rice develops off-aromas at a faster rate. It is thought that the removal of anti-oxidants hastens breakdown of fatty acid components.

Outcomes

This work demonstrated the potential of the zNose technology as a rapid, objective and relatively inexpensive method of assessing changes in aroma of rice and rice products.
The work highlights the importance of specific compounds and these will be identified. It also suggests the importance of anti-oxidants in minimising the developments of off-aromas during storage.

**Glycaemic index studies of rice (4505)**

*Project Leader:*
Mr Phillip Williams  
SunRice  
Leeton

This project includes work being undertaken and supervised by Dr Melissa Fitzgerald (currently based with IRRI in the Philippines) on resistant starch. An update on this work is also provided.

*Resistant Starch (Melissa Fitzgerald)*

**Objectives**

1. To understand how class 2 Resistant Starch (RS) (naturally occurring) and class 3 RS (retrograded) varies between different varieties of rice.

2. To determine whether class 2 or class 3 RS relates to Glycaemic Index (GI).

3. To understand the structure of RS classes 2 and 3.

4. To determine the range of RS in mutants which either do not express or over-express different genes, leading to an understanding of how starch structure affects RS.

**Progress**

1. Resistant Starch (RS) has been measured in nine varieties of rice using the Megazyme® kit. Non-resistant starch was also measured. The rice varieties are Amaroo, Basmati, Doongara, Koshihikari NSW, Koshihikari Japan, Kyeema, Langi and Opus. PSB Rc10 was also included, which is an indica of intermediate amylose, known for satiety.

The method involves collecting a supernatant (containing the digested starch) and a pellet (containing the resistant starch). The starch in the supernatant is termed Non-Resistant Starch (NRS). Table 3 shows the values for RS, NRS, the difference between the two, and several other chemical properties. The varieties of intermediate amylose show slightly higher values of RS than the others, and the low amylose varieties fall into two groups. Koshihikari grown in Japan contained less RS than when it was grown in NSW. Residual amylose in Table 3 refers to the iodine binding value for the pellet (containing the RS), suggesting that RS is not explained by amylose. Project staff are still optimising the method to determine where the rest of the starch is. The analysis of RS in these rice varieties in their retrograded state has yet to be completed.
Table 3.

### Physicochemical characteristic and resistant starch of SunRice varieties with PSB Rc10

<table>
<thead>
<tr>
<th>Variety</th>
<th>Amylose content (%)</th>
<th>Alkali Spreading Value</th>
<th>Gel. Temp.</th>
<th>RS (%)</th>
<th>NRS (%)</th>
<th>Total Starch (%)</th>
<th>Residual Amylose (P2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>43.46</td>
<td>41.03</td>
<td>84.49</td>
<td>5.54</td>
</tr>
<tr>
<td>Basmati</td>
<td>24</td>
<td>6.28</td>
<td>L</td>
<td>2.67</td>
<td>69.50</td>
<td>72.17</td>
<td>1.64</td>
</tr>
<tr>
<td>Doongara</td>
<td>25</td>
<td>6.06</td>
<td>L</td>
<td>2.15</td>
<td>70.60</td>
<td>72.75</td>
<td>1.36</td>
</tr>
<tr>
<td>PSB Rc10</td>
<td>26</td>
<td>7.00</td>
<td>L</td>
<td>1.88</td>
<td>69.20</td>
<td>71.08</td>
<td>1.83</td>
</tr>
<tr>
<td>Koshihikari NSW</td>
<td>19</td>
<td>7.00</td>
<td>L</td>
<td>1.30</td>
<td>66.90</td>
<td>68.2</td>
<td>2.66</td>
</tr>
<tr>
<td>Amaroo</td>
<td>19</td>
<td>7.00</td>
<td>L</td>
<td>1.26</td>
<td>67.80</td>
<td>69.06</td>
<td>1.5</td>
</tr>
<tr>
<td>Langi</td>
<td>19</td>
<td>5.22</td>
<td>I/H/I/L</td>
<td>1.24</td>
<td>66.00</td>
<td>67.24</td>
<td>1.93</td>
</tr>
<tr>
<td>Opus</td>
<td>19</td>
<td>7.00</td>
<td>L</td>
<td>1.17</td>
<td>73.10</td>
<td>74.27</td>
<td>1.17</td>
</tr>
<tr>
<td>Koshihikari Japan</td>
<td>18</td>
<td>7.00</td>
<td>L</td>
<td>0.97</td>
<td>71.80</td>
<td>72.77</td>
<td>1.91</td>
</tr>
<tr>
<td>Kyeema</td>
<td>20</td>
<td>4.39</td>
<td>I/L</td>
<td>0.89</td>
<td>62.20</td>
<td>63.09</td>
<td>1.35</td>
</tr>
</tbody>
</table>

2. Since rice is primarily starch and the product from the digestion of starch is glucose, it is expected that Glycaemic Index (GI) and RS will relate to each other in some way. RS and GI were tested on sub-samples of the same set of varieties. The GI of these rices is being reported separately since the data set is too small and too narrow to allow a relationship to be drawn.

3. Studies on the structure of the RS in class 3 have not yet been completed.

The structure of Class 2 RS has been determined by analysing the hydrodynamic volume of the RS and the chain length distribution of the debranched RS from cooked rice of each variety. Hydrodynamic volume was determined by injecting the RS into a gel permeation column and separating the molecules with Size Exclusion Chromatography fitted with online multi-angle laser light scattering, which gives the absolute molecular weight of the molecules. Figure 21 shows the chromatograms for the molecules of RS. Figure 21a shows the whole distribution and Figure 21b focuses on the chains that are long enough to be amylose. Figure 21 shows that a very small amount of amylose remains in the RS. The other component of the RS is molecules of low molecular weight. The highest peak is for Basmati. The average molecular weight (MW) of the amylose chains (Figure 21b) is DP (degrees of polymerisation) 700, and the MW of the other molecules was not detectable.
Based on previous work in Project 3402 ("Understanding amylose structure: what it controls and what controls it"), it is known that the molecules in Figure 21a are highly branched, and are likely to be the dextrin remaining from digestion.

The RS was debranched and analysed by Capillary Electrophoresis (CE). By using this technique, base-line separation of individual branches can be achieved. Whole flour of each variety was also debranched for comparison between the chain length distribution of the amylopectin in the full flour and of the remainder of amylopectin molecules in RS.

Figure 22 shows the CE traces of Doongara (high RS), Kyeema (lowest RS) and the two Koshihikari samples (NSW or Japanese grown). The electropherograms of debranched RS are overlaid on those of the full flour of each variety.

Figure 22 shows that there are proportionally far fewer short chains of amylopectin (DP 6 - DP 25) in the RS than in the flour, suggesting that the short chains are easily accessible to the digestive enzymes. The amount of glucose, maltose and malto-triose in the RS suggests that the digestive enzymes used could not hydrolyse the chains close to branch points. Glucose units attached beyond the branch points would be protected by the branch. Figure 22 shows that Doongara retained longer chains than Kyeema; complete hydrolysis to glucose of a longer chain gives more glucose than a shorter chain. Thus Doongara showed more RS than Kyeema. The data suggest that the RS is mostly due to the amylopectin fraction and not the amylose fraction, as would be intuitively expected. The tertiary architecture of the amylopectin molecule, in terms of the distribution of the branches, is likely to be a key factor determining how much the branches can protect the chains of glucose. More of each chain was digested for the Koshihikari grown in Japan than the Koshihikari grown in Australia, consistent with the result obtained for their RS content. Since these rices are likely to be genetically identical, the difference suggests that environmental conditions affect the synthesis of amylopectin and its tertiary structure.
Figure 22: Chain length distribution of amylopectin from full flour and resistant starch (overlaid) of four varieties.

4. The range of RS in mutants which either do not express or over-express different genes leading to an understanding of how starch structure affects RS has not been completed as CAMBIA and CSIRO have yet to supply the rice.

Future work

Carry out structural studies on the RS of rices in the retrograded state. Analyse the data to solve the apparent contradiction that amylose seems to be easily digested, but those with higher amylose show higher resistant starch.
Progress

Eight milled rices were prepared, half of each rice sample set aside. One half of each sample was sent for Glycaemic Index (GI) analysis at the University of Sydney and the other half placed in room temperature storage to be tested for GI after one year of aging.

Each rice sample was analysed for proximate composition and amylose content before GI testing to determine available (digestible) carbohydrate content.

To date the first set of samples from 2003 have been analysed for GI. The GI testing for the samples stored for one year is being conducted at present. The results for these samples are expected by early September 2005.

The GI of all eight rice samples was determined when the rice was consumed hot, i.e. - just after cooking and when the rice was consumed cold (ie - after about two days storage in a refrigerator). Cooling the rice to refrigerator temperatures (approximately 4°C) may increase the resistant starch content and perhaps result in a lower GI value.

Outcomes

Results for the resistant starch component of this project are reported separately.

### Analytical data for 2003 Rice GI samples

<table>
<thead>
<tr>
<th></th>
<th>Amaroo</th>
<th>Doongara</th>
<th>Langi</th>
<th>Opus</th>
<th>Kyeema</th>
<th>NSW Koshihikari</th>
<th>Japan Koshihikari</th>
<th>Pakistan Basmati</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture %</td>
<td>12.5</td>
<td>12.1</td>
<td>12.3</td>
<td>12.1</td>
<td>12.1</td>
<td>1.6</td>
<td>13.5</td>
<td>12.5</td>
</tr>
<tr>
<td>Protein % N*6.25</td>
<td>7.0</td>
<td>7.4</td>
<td>8.5</td>
<td>7.1</td>
<td>7.7</td>
<td>6.5</td>
<td>5.8</td>
<td>8.1</td>
</tr>
<tr>
<td>Ash %</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Fat %</td>
<td>1.0</td>
<td>1.4</td>
<td>0.9</td>
<td>0.9</td>
<td>1.0</td>
<td>0.9</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Total Dietary Fibre %</td>
<td>0.6</td>
<td>0.7</td>
<td>0.5</td>
<td>0.4</td>
<td>0.6</td>
<td>0.6</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Total Starch by analysis %</td>
<td>78.5</td>
<td>78.0</td>
<td>77.5</td>
<td>80.0</td>
<td>80.0</td>
<td>81.5</td>
<td>80.0</td>
<td>78.5</td>
</tr>
<tr>
<td>Amylose %</td>
<td>18.3</td>
<td>24.3</td>
<td>18.4</td>
<td>17.1</td>
<td>18.0</td>
<td>16.6</td>
<td>15.2</td>
<td>22.6</td>
</tr>
</tbody>
</table>
### Glycaemic Index Values for Rice

<table>
<thead>
<tr>
<th>Rice variety</th>
<th>GI Value Hot</th>
<th>G.I. Range</th>
<th>GI Value Cold</th>
<th>G.I. Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amaroo</td>
<td>89 ±8</td>
<td>High</td>
<td>79 ±6</td>
<td>High</td>
</tr>
<tr>
<td>Opus</td>
<td>85 ±12</td>
<td>High</td>
<td>69 ±18</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Kyeema</td>
<td>79 ±10</td>
<td>High</td>
<td>62 ±7</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Langi</td>
<td>76 ±9</td>
<td>High</td>
<td>62 ±8</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Koshihikari Japan</td>
<td>68 ±8</td>
<td>Intermediate</td>
<td>69 ±5</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Koshihikari NSW</td>
<td>61 ±8</td>
<td>Intermediate</td>
<td>64 ±7</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Basmati Pakistan</td>
<td>59 ±6</td>
<td>Intermediate</td>
<td>58 ±6</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Doongara</td>
<td>51 ±6</td>
<td>Low</td>
<td>56 ±7</td>
<td>Intermediate</td>
</tr>
</tbody>
</table>

**GI Ranges***

<table>
<thead>
<tr>
<th>GI Level</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low GI</td>
<td>Below 55</td>
</tr>
<tr>
<td>Intermediate GI</td>
<td>Between 55 and 70</td>
</tr>
<tr>
<td>High GI</td>
<td>More than 70</td>
</tr>
</tbody>
</table>


The GI results confirm the low/lower GI status of both Doongara and Basmati rice. Also confirmed by these results are the expected high GI of Amaroo, Langi, Kyeema and Opus. The two Koshihikari samples were found to have an intermediate GI. This result doesn’t fit the trend of lower amylose content giving a high GI value. Previous Australian rice cultivars tested for GI have found only Doongara to have a GI below 60. This has been thought to be due to the higher amylose content of Doongara.

Thus if amylose content alone causes the lower GI response, the two Koshihikari samples could be expected to have a high GI, since their amylose contents are lower than all other rice samples included in this study. However the GI results for the two Koshihikari samples don’t fit the trend of lower amylose content producing high GI response. The reasons for this are not known and further work to confirm and understand this observation is required.

GI values after cooling decreased in the samples which had the higher hot GI values, however for the rice samples that had low or intermediate hot GI values, the cold GI value were found to remain about the same as the hot GI value. The reasons for this are not clear and further work to investigate this observation is required.

**Future work**

Work investigating resistant starch and other starch attributes is being undertaken at IRRI by Dr Melisssa Fitzgerald as part of this study. This work may assist in understanding why Koshihikari has an intermediate GI.
### MILESTONES

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Grain quality in the pre-milling phase</td>
<td></td>
<td></td>
<td></td>
<td>Achieved prior to Year 7</td>
</tr>
<tr>
<td>Appointment of scientific officer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampling procedures optimised</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual grain moisture distribution monitored</td>
<td></td>
<td></td>
<td></td>
<td>Achieved prior to Year 7</td>
</tr>
<tr>
<td>Optimum grain drying strategies developed</td>
<td>X ✔</td>
<td>X ✔</td>
<td></td>
<td>Achieved prior to Year 7</td>
</tr>
<tr>
<td>Training programs developed</td>
<td>X ✔</td>
<td></td>
<td></td>
<td>X ✔ Completed</td>
</tr>
<tr>
<td>Training programs implemented</td>
<td>X ✔</td>
<td>X ✔</td>
<td>X ✔</td>
<td></td>
</tr>
<tr>
<td>4.2 Development of rice handling in-line process control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software development</td>
<td></td>
<td></td>
<td></td>
<td>Achieved prior to Year 7</td>
</tr>
<tr>
<td>Closed loop control developed for degree of milling/whitening</td>
<td></td>
<td></td>
<td></td>
<td>Achieved prior to Year 7</td>
</tr>
<tr>
<td>Moisture meter interface developed</td>
<td></td>
<td></td>
<td></td>
<td>Achieved prior to Year 7</td>
</tr>
<tr>
<td>Packer weigher interface developed</td>
<td></td>
<td></td>
<td></td>
<td>Achieved prior to Year 7</td>
</tr>
<tr>
<td>Process weigher interface developed</td>
<td></td>
<td></td>
<td></td>
<td>Achieved prior to Year 7</td>
</tr>
<tr>
<td>Closed loop system to maximise hulling efficiency developed</td>
<td>X ✔</td>
<td>X ✔</td>
<td>X Deferred</td>
<td>X Deferred</td>
</tr>
<tr>
<td>X Deferred</td>
<td>X Deferred</td>
<td>X In process</td>
<td>X Deferred to Year 8</td>
<td></td>
</tr>
<tr>
<td>System implementation</td>
<td>X Deferred</td>
<td>X In process</td>
<td></td>
<td></td>
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<tr>
<td>4.3 Quality assurance systems and post-harvest pest management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPM strategies evaluated</td>
<td></td>
<td></td>
<td></td>
<td>X Discontinued</td>
</tr>
<tr>
<td>Ethyl formate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ fumigation</td>
<td></td>
<td></td>
<td></td>
<td>Achieved prior to Year 7</td>
</tr>
<tr>
<td>Cool temperature treatment</td>
<td>X ✔</td>
<td>X ✔</td>
<td></td>
<td>Not successful</td>
</tr>
<tr>
<td>Phosphine fumigation</td>
<td>X Discontinued</td>
<td>X Discontinued</td>
<td></td>
<td>Achieved prior to Year 7</td>
</tr>
<tr>
<td>Carbonyl sulphide</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Designing out pests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HACCP systems</td>
<td></td>
<td></td>
<td></td>
<td>Achieved prior to Year 7</td>
</tr>
<tr>
<td>Rice-based foods plant</td>
<td>X RCL</td>
<td>X RCL implementation</td>
<td>X ✔ Six Sigma implementation</td>
<td></td>
</tr>
<tr>
<td>Mills and stock food plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice receival sheds and on-farm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.4 Rice hull use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential for energy conversion determined</td>
<td></td>
<td></td>
<td></td>
<td>No potential n/a</td>
</tr>
<tr>
<td>Potential for hull-based alternatives determined</td>
<td></td>
<td></td>
<td></td>
<td>X RCL</td>
</tr>
<tr>
<td>Other uses for hulls investigated</td>
<td>X RCL</td>
<td>X RCL implementation</td>
<td>X RCL implemented</td>
<td>X ✔ RCL implemented</td>
</tr>
<tr>
<td>4.5 New rice-based foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quick cook rices developed</td>
<td>X ✔</td>
<td>X ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feasibility for pouch-packed cooked &amp; frozen rice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frozen rice products developed &amp; test marketed</td>
<td></td>
<td></td>
<td></td>
<td>In process</td>
</tr>
<tr>
<td>Development of pouch packed products</td>
<td>X ✔</td>
<td>X ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluation of waxy rice flour</td>
<td>X ✔</td>
<td></td>
<td></td>
<td>Other flours</td>
</tr>
<tr>
<td>Potential to produce and market rice noodles evaluated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other rice-based products evaluated</td>
<td>X ✔</td>
<td>X ✔</td>
<td>X ✔</td>
<td>X ✔ retort rice</td>
</tr>
</tbody>
</table>

90
<table>
<thead>
<tr>
<th>Milestones for additional Year 8</th>
<th>Year 8 – 2004/2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>New rice products:</td>
<td></td>
</tr>
<tr>
<td>• Development of new uses for rice flour to extend the range of varieties that can be used for this market segment.</td>
<td>✔</td>
</tr>
<tr>
<td>• New products developed based on retort, thermal processing or similar processes.</td>
<td>✔</td>
</tr>
<tr>
<td>• Continued roll-out for Quality Assurance programs in the processing sector.</td>
<td>✔</td>
</tr>
<tr>
<td>Rice quality at receival:</td>
<td>Partially completed</td>
</tr>
<tr>
<td>• Development of a regression between grain characters at receival and milling quality.</td>
<td>X</td>
</tr>
<tr>
<td>• Development of a manual for use of the technology.</td>
<td></td>
</tr>
</tbody>
</table>

X = To be completed (in some cases this exercise is spread over several years). ✔= Achieved (if not achieved, status provided.)

**NB:** After obtaining approval from the CRC Secretariat, comments on milestones for Years 1 to 3 inclusive have been removed from this table. Please refer to previous Rice CRC Annual Reports if you wish to view this information or contact the Rice CRC for additional information.
A brief snapshot of achievements within Program 5 during the life of the Rice CRC

Education at all levels has been a key component of the CRC program. There has been good cooperation across the CRC partners and education has involved a mix of students, providers, researchers and industry participants. There have been many highlights. Some of these include:

- Widespread use of imaging of rice crops to assist management decisions.
- Successful field days and meetings to transfer CRC technology to rice growers.
- Development and delivery of vocational courses for the farming and processing sectors of the rice industry.
- Very successful extension of information on rice to international visitors, community groups and school groups.
- Successful “Chairman’s Tours” to introduce CRC participants to industry issues.
- Development and delivery of tertiary courses in irrigation, agronomy and food processing.
- Successful summer student, Honours, Masters and PhD training programs that involved industry participants and developed a skilled human resource.
EDUCATION AND TRAINING

Education is a cornerstone of the CRC for Sustainable Rice Production. It is administered as a separate program (Program 5) but it has links to all research programs through its role in administration of postgraduate students and in transfer technology.

The research aspects of the education and training program are reported in this section along with the general aspects of education and training in the Rice CRC.

PROGRAM 5

EDUCATION, SKILLS DEVELOPMENT AND TECHNOLOGY TRANSFER

Program Leader:
Dr Philip Eberbach
Charles Sturt University
Wagga Wagga

Expediting the findings of research to achieve grower outcomes is a major focus for the CRC for Sustainable Rice production. Program 5 has as its core business the transfer of knowledge generated by the other programs into practice. To achieve this, the Program:-

* provides information about rice production and processing to schools and the greater community;

* provides information about new research to the community;

* provides vocational training to people involved in grain production and processing;

* facilitates tertiary training at the undergraduate level;

* finances research training at the honours and postgraduate level; and

* conducts research into information adoption to improve the realisation of knowledge into practice.

Please note that information regarding technology transfer and training provided to end users is also provided in the “Commercialisation/Technology Transfer/Utilisation”, “Publications” and “Communication Strategy” chapters of the Annual Report.
5.1 Sustainable rice production through farmer education and community awareness (5101)

Sub-Program/Project Leader:
Mr John Lacy
NSW Dept Primary Industries, Yanco

The aim of this Sub-Program is to raise awareness of Rice CRC objectives and progress with the farming community. This has been facilitated through the network of NSW Dept Primary Industries District Agronomists.

The agronomist team continued the education and training of farmers in aerial imaging and participated in the project “Identification of factors causing variable rice growth and crop yields” for the 2004/2005 season.

Objectives

The project aim is to improve rice yields. Objectives are to:

1. educate farmers in the use and interpretation of aerial images;
2. identify the factors influencing rice crop growth variability and crop yield; and
3. increase the number of aerial imaged crops compared to 2003/2004 by 20%.

Progress

The project builds on the progress from 2003/2004. NSW DPI District Agronomists continued to educate farmers in the use of images at PI meetings, although many farmers are past the awareness phase. Hence the project did not provide a number of free images as in previous seasons. The project only paid for images of crops participating in objective 2. Most infra red aerial images were taken by a satellite with an aircraft used for isolated crops. Images were supplied at commercial rates of $3.85/ha directly to farmers and retail agronomists by Terrabyte Services.

A reduced number of 20 crops were monitored in 2004/2005 compared to 2003/2004. This on-ground survey was conducted throughout the season to determine the factors causing crop growth and yield variability as identified from the aerial images. In 2004/2005 (in contrast to 2003/2004) soil samples were taken prior to rice sowing. Data and results are being tabulated. The variation of measured parameters within the one crop, eg - plant number, water depth and N uptake, has been surprisingly high. It has been difficult sorting the 2003/2004 data into meaningful results but good progress is now being made. The coefficient of variation for each parameter within the one crop is often 30%. This methodology will be used for the 2004/2005 results. The Rice Education Officer at Yanco and Rice Technical Officer, Finley monitored two to four crops from each District Agronomist district. The Rice Education Officer (Peter Evans) resigned in January 2005, with the work continued by the District Agronomists with assistance from research staff.
The low area of rice for the 2004/2005 season of 44,000 ha compared to 63,000 ha in 2003/2004 would be expected to result in a reduced area imaged. However areas were similar, with 29,000 ha imaged both years. The area in 2004/2005 represents 66% of the total crop compared to 47% area in 2003/2004, which shows increased adoption of aerial imaging.

In 2003/2004 there were a number of teething problems in timing of delivery of the images. In 2004/2005 there were no problems. Collaborative teamwork by NSW DPI and retail agronomists and Terrabyte has resulted in aerial imaging being accepted as an essential tool for identifying sampling areas for the NIR test and for evaluating crop variability. The area imaged as a proportion of the total crop area will continue to increase, thus assisting in lifting rice yields and profitability.

5.2 Extension and information technology methods

Sub-Program Leader:
Mr A (Tony) Dunn
Charles Sturt University
Wagga Wagga

The development of sustainability in Australian rice: implications for agricultural extension (5204)

Project Leader:
Mr A (Tony) Dunn
Charles Sturt University
Wagga Wagga

Objectives

To analyse conflicting values and interests in order to inform agricultural extension efforts to cultivate sustainable rice farming and enhance an emergent paradigm for the facilitation of sustainable agriculture.

Progress

Since the last Annual Report (2003/2004) there has been additional data collection via a telephone survey of Coleambally rice growers, to which there was an 80% response rate.

Andy Brown (PhD student) has finished his field work and most of the data analysis. He is now writing his thesis.

Mr Brown drafted a paper titled “From agricultural to agro-eco-cultural extension” for the International Extension Education Conference held in Dublin in 2004. However despite being peer reviewed and accepted, he had to withdraw his paper because of his field work. He was encouraged to resubmit in 2005.

Outcomes
The development of sustainability in Australian rice: Implications for agricultural extension. An emergent agricultural extension paradigm to facilitate sustainability recommends an initial analysis of conflicting values and interests to inform the process. However, there is a lack of coherent guidelines to conduct the recommended analysis. This study demonstrates that the initial analysis can be conducted from a sociological perspective on rural development. The aim of the study then, is to augment the extension paradigm in question and contribute towards sustainability in the rice landscape.

5.3 Sustainable rice production through skills development

Sub-Program Leader:
Mr Geoff Creek
Murrumbidgee College of Agriculture
Yanco

This Sub-Program operates at two levels. The first aims at developing the skills base for industry participants at all levels. The second is to increase awareness of the rice industry and particularly rice research, through schools and the community.

Sustainable rice production through skills development (5301)

Project Leader:
Mr Peter Evans
Murrumbidgee College of Agriculture
Yanco

Objectives

The project aims to deliver information to stakeholders within the rice industry, through links with NSW Dept Primary Industries’ District Agronomists (DA’s), educational courses and field days.

Progress

The position of education officer was re-appointed to fulfil the objectives of the program. New links have been created with District Agronomists, farmers and researchers through the position. This link has been critical in forming a relationship to enable vital educational material to be passed onto farmers.

Outcomes

* A very successful “Rice for Profit” course was held at Murrumbidgee College of Agriculture. A total of 26 participants attended the course, comprising of farmers, fertiliser representatives, agronomists and managers. The three day course covered all aspects of a rice growing system. The education officer coordinated and facilitated sessions throughout the course.
* Rice discussion groups. Materials for these discussion groups were prepared by the education officer. The education officer was also in attendance at a selection of these meetings.

* Rice imaging project. Mr Evans was very heavily involved in this project, covering the ground truthing and data collection in the northern areas of the rice growing regions, working closely with District Agronomists.

* A number of new courses have begun to be developed for rice growers including a precision agriculture course.

**Rice CRC education officer (5302)**

**Project Leader:**
Mrs Robyn Troldahl
Rice CRC
Yanco

**Objectives**

The project aims to deliver information to school students, the general community and international visitors on the rice industry, rice research and Rice CRC Programs.

**Progress**

The Education Officer position was extended until June 2005. Enquiries from schools, community groups and individuals for information on the Australian rice industry and Rice CRC programs have remained high. Groups visiting Yanco to gain information on the Australian rice industry have been constant. Resources and display material are constantly being updated.

**Outcomes**

* Rice-based presentations were given at Yanco Agricultural Institute to:
  - international visitors mainly from Japan, also from Cambodia, Columbia and Korea;
  - HSC students from throughout NSW studying rice for agriculture, geography and food technology subjects;
  - Girl Guides groups and coach tours from interstate;
  - delegates on a “Weeds and Water” conference field trip.

* Mr Bert Berghuis, a primary school teacher in northern NSW, visited the Rice CRC to learn about the Australian rice industry. Mr Berghuis was awarded the NSW Premier’s Teacher Scholarship for Environmental Education. Information from his study tour will be used to develop teaching resources linked to the HSIE Rice Growing Cycle Program.
* “Rice is Life” talk given to the general public visiting the CSIRO Discovery centre in Canberra, providing the visitors with an awareness of the Australian rice industry.

* Classroom visits to two primary schools in Yass to celebrate the International Year of Rice. The aim was to raise awareness of the Australian rice industry through a range of “hands on” activities, eg - sushi making, using chopsticks, rice collage, making faces from cooked rice, mapping rice producing countries, growing rice in the classroom, demonstrations of hulling and milling rice. This was a very successful project.

* Responded to schools and also web enquiries with written material on rice, as well as coordinating provision of seed rice to school groups to grow rice as school projects.

* Hosted CRC display at Murrumbidgee Farm Fair, Yanco and SunRice Festival, Leeton;

* Participated in the Education hub at the Australian rice industry’s record attempt to cook the World’s Biggest Risotto at Circular Quay, Sydney. The Rice CRC display was educational and interactive, generating interest from the general public and school students.

Scenes from the “World’s Biggest Risotto” successful record attempt in Sydney in November 2004, including Rice CRC “Education Hub”
5.4 Professional development for sustainable rice production (5401)

Sub-Program/Project Leader:
Dr Philip Eberbach
Charles Sturt University
Wagga Wagga

The Sub-Program’s principal function is the provision of training at the tertiary level. The Program sponsors two education officers at Charles Sturt University in the areas of rice agronomy and cereal technology. The specific objectives of the Sub-Program are to:-

* provide undergraduate and postgraduate course material and the experiences necessary to assist in the professional development of students intending to work in the rice production and processing industries;

* provide postgraduate study opportunities within each of the Rice CRC research programs; and

* provide training and education opportunities at the postgraduate level to enable the extension and research personnel already employed with the rice industry to further develop their qualifications and experience.

Progress

The work undertaken in this Sub-Program builds on the efforts of previous years. Select undergraduate subjects developed in this Program are being taught both at CSU and at the CRC partner education institution, University of Sydney. The subjects developed through this Sub-Program are well embedded into the course structure at each University and will continue into the future, satisfying student demand for subjects which focus on rice production and processing.

The two education officers have successfully integrated teaching with research training.

Visiting scientist program, conference attendance and scientific visits (5403)

Project Leader:
Dr Laurie Lewin
CRC for Sustainable Rice Production
Yanco

Objectives

To provide opportunities for scientific exchange with international scientists through facilitating exchange and conference attendance.
Progress

The Rice CRC has supported opportunities for exchange of scientific information on an international basis through international conference attendance, study tours, sponsoring visiting scientists etc.

As part of the CRC’s International Cold Tolerance Workshop in July 2005 which was held in Canberra, eight international scientists were sponsored to come to Canberra and give presentations and exchange ideas. In particular, Dr Renata Pereira da Cruz (Instituto Rio Grandense do aroz, Cachoeirinha, Brazil) was invited to extend her visit to Australia to meet with CRC staff at Yanco Agricultural Institute and the University of Sydney.

In September 2004 the CRC also sponsored a visit by Prof Takeshi Horie (Kyoto University, Japan) who gave a presentation at the 4th International Crop Science Congress in Queensland, Australia and also took the time to meet with CRC staff at CSIRO Plant Industry in Canberra.

Prof Chung (Kyungpook National University, Taegu, South Korea) worked with participants in Project 1301 for six months, based at CSIRO Land & Water in Griffith, NSW.

Professor Shahbaz Khan (CSU/CSIRO) and his team hosted a high level (Steering Committee) visit of International Challenge Program on Water and Food to the Murray Irrigation Area (March 2005).

CRC staff have undertaken approx. 14 overseas visits. Various CRC staff have participated in at least three international workshops/conferences during 2004/2005.

5.5 Studentships

Sub-Program Leader:  
Dr Philip Eberbach  
Charles Sturt University  
Wagga Wagga

Postgraduate student scholarships and work experience (5501)

Project Leader:  
Dr Philip Eberbach  
Charles Sturt University  
Wagga Wagga

In 2004/2005 the CRC supported 13 postgraduate students as shown in the Table below.

<table>
<thead>
<tr>
<th>Scholarship Package</th>
<th>2004/2005 Student Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD Scholarship Package</td>
<td>9</td>
</tr>
<tr>
<td>PhD Top Up Award</td>
<td>2</td>
</tr>
<tr>
<td>Masters Scholarship Package</td>
<td>2</td>
</tr>
</tbody>
</table>

1 of these PhD students has now gone on to a Post Doctorate Fellowship.  
1 of the Masters students is already an employee of a government department. 
To date (ie – from July 1997 to July 2005) the CRC has supported:
* 32 PhD scholarships - 7 of which withdrew for personal reasons. Of the 11 students funded in 2004/2005, 6 are still to finalise their thesis, although a few of these expect to submit their thesis shortly after 30 June 2005. All of the other previously funded PhD students have published their thesis except for 1 student who is doing revisions.

* 9 Masters students (not including one student who subsequently withdrew). There has been 2 “funded” Masters students in 2004/2005. One has submitted his first draft of his thesis to his supervisor for review and the other is still to finalise his thesis.

Including current students, 16 PhD students have gone on to find employment (3 private enterprise and 13 University/Govt research organisations) and 8 Masters students have gone on to find employment (6 private enterprise and 3 University/Govt research organisations). Of these, 2 PhD students have found overseas employment.

**Honours student program (5505)**

**Project Leader:** Dr Philip Eberbach  
**Charles Sturt University**  
Wagga Wagga

In the life of the Rice CRC, 10 Honours scholarships have been supported, with all students having graduated. Four additional Honours scholarships were provided but these students subsequently withdrew. Four students went on to gain employment in private enterprise, 2 with universities/government research organisations and 3 went on to further studies. One of these students gained employment overseas.

**5.6 External communications (5601)**

**Sub-Program Leader:** Dr Laurie Lewin  
**Project Leader:** Vacant  
**Rice CRC**  
Yanco

Since the last Annual Report the CRC concluded its contract with the Communications Officer. The communication activities were taken over and shared by the remaining CRC office staff – particularly the Communications Assistant, Education Officer and Executive Secretary.

**Objectives**

The project aims to promote awareness and understanding of the Centre and its achievements among rice and irrigation industry participants, the broader community and government at all levels.

Specific objectives are to:-
* acquaint the community with Rice CRC philosophies and emphasise the vital nature of its research activities, extension services and education programs;

* market the uptake of Rice CRC research outcomes by industry;

* support and enhance the Rice CRC’s linkages; and

* develop and maintain a strong, productive relationship with the print and electronic media.

Progress/Outcomes

During the last 12 months the following communication activities have occurred, in addition to items listed in the Education Officer’ report (Project 5302):

* CRC display at CRC Association Conference, June 2004;
* production of CRC research reports and distribution;
* general maintenance of CRC website;
* outsourced drafting of press releases to freelance journalist (Alex Nicol) and arranged interviews with CRC staff accordingly;
* issued 22 press releases (available on CRC website) which were also made available to Australian Grain Magazine and “Ag Today” (supplement in The Land produced by NSW DPI);
* produced 5 editions of Rice CiRCle (internal newsletter) and 2 editions of Rice Update (external) newsletter;
* provided contributions to RGA E-Bulletin;
* produced CRC flyer on its involvement in International Year of Rice which was distributed to participants at RGA Annual Conference, where CRC static display was also on show;
* produced CRC brochure on some of its achievements to date which was provided for distribution at 4ICSC conference to 1100 participants;
* provided photos and approved articles for CRCA Conference Highlights Booklet; and
* arranged media coverage for the 2005 Rice CRC Symposium.
<table>
<thead>
<tr>
<th>Name</th>
<th>Project Commencement Date</th>
<th>University</th>
<th>Type of enrolment</th>
<th>Primary Location</th>
<th>CRC Project Title</th>
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</thead>
<tbody>
<tr>
<td>Mr Sanjeev Alfred</td>
<td>30-7-01</td>
<td>Univ of Sydney</td>
<td>PhD</td>
<td>University of Sydney</td>
<td>Assimilate transfer in rice anthers (3202a)</td>
</tr>
<tr>
<td>Mr David Allen</td>
<td>July 2002</td>
<td>Univ of Technology Sydney</td>
<td>Masters</td>
<td>University of Technology Sydney</td>
<td>Continuous salinity imaging along canals and drains (Sub-Program Sub-Program 1.4)</td>
</tr>
<tr>
<td>Ms Louisa Best</td>
<td>2-1-01</td>
<td>Charles Sturt Univ</td>
<td>PhD</td>
<td>CSIRO Land &amp; Water, Griffith</td>
<td>Risk based spatial modelling to identify regional soil salinity trends in irrigation areas (1403a)</td>
</tr>
<tr>
<td>Ms Louisa Best</td>
<td>2-1-01</td>
<td>Charles Sturt Univ</td>
<td>PhD</td>
<td>CSIRO Land &amp; Water, Griffith</td>
<td>Risk based spatial modelling to identify regional soil salinity trends in irrigation areas (1403a)</td>
</tr>
<tr>
<td>Mr Andrew Brown</td>
<td>1-3-01</td>
<td>Charles Sturt Univ</td>
<td>PhD</td>
<td>CSU Wagga Wagga but recently moved to Adelaide personal reasons and is writing up thesis</td>
<td>The Research &amp; Development of Agricultural Extension: Implications for Agricultural Extension, (5204)</td>
</tr>
<tr>
<td>Mr Jeffrey Castro</td>
<td>1-3-01</td>
<td>Univ of Sydney</td>
<td>PhD</td>
<td>University of Sydney</td>
<td>Customising molecular architecture of starch for rice quality - biochemistry aspects (3404)</td>
</tr>
<tr>
<td>Mr Herbert Chiou1</td>
<td>19-3-01</td>
<td>Univ of Sydney</td>
<td>PhD</td>
<td>Primarily University of Sydney</td>
<td>Customising molecular architecture of rice polymers for rice cooking quality – characterisation aspects (Structure-Property relationship of rice starch) (3405).</td>
</tr>
<tr>
<td>Mr Greg Doran</td>
<td>29-1-01</td>
<td>Charles Sturt Univ</td>
<td>PhD</td>
<td>CSU Wagga Wagga</td>
<td>Downstream impacts on the environment (The determination of the role of sediments in the persistence of pesticides in rice floodwaters and drains) (1302)</td>
</tr>
<tr>
<td>Mr Vincent Lanoiselet</td>
<td>6-8-01</td>
<td>Charles Sturt Univ</td>
<td>PhD</td>
<td>CSU Wagga Wagga</td>
<td>Stem diseases in rice (Leaf sheath diseases of rice caused by <em>Rhizoctonia</em> species in south-eastern Australia) (2409).</td>
</tr>
<tr>
<td>Mr Zhongan Li</td>
<td>7-12-01</td>
<td>Univ of Sydney</td>
<td>PhD</td>
<td>University of Sydney</td>
<td>Control of callose synthesis and dissolution in rice anthers (3202b)</td>
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<tr>
<td>Ms Sandra Oliver</td>
<td>20-2-01</td>
<td>Charles Sturt Univ</td>
<td>PhD</td>
<td>CSIRO Plant Industry, Canberra</td>
<td>Identification and characterisation of genes affected by cold treatment of rice anthers (3209)</td>
</tr>
<tr>
<td>Ms Skye Wassens</td>
<td>5-3-01</td>
<td>Charles Sturt Univ</td>
<td>PhD</td>
<td>CSU Wagga Wagga</td>
<td>Conservation biology of the endangered Southern Bell Frog (2408)</td>
</tr>
<tr>
<td>Mr John Smith</td>
<td>Jan 2002</td>
<td>Univ of Qld</td>
<td>Masters</td>
<td>NSW DPI Deniliquin</td>
<td>Screening reproduction-stage cold tolerance for NSW Rice Improvement Program (2206)</td>
</tr>
<tr>
<td>Ms Kahlia Weir</td>
<td>1-3-01</td>
<td>Charles Sturt Univ</td>
<td>PhD</td>
<td>CSIRO Entomology Canberra</td>
<td>Enzymatic bioremediation for pesticide residues in irrigation tailing water (Isolation and characterisation of pesticide degrading enzymes) (1304)</td>
</tr>
</tbody>
</table>

1 As at May 2004 working as Research Only Academic, Faculty of Pharmacy, Univ of Sydney but will be Post Doctoral Research Fellow after graduates.
## Milestones

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Year 8 – 2004/2005</th>
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</thead>
<tbody>
<tr>
<td>5.1 Farmer education and community awareness</td>
<td></td>
<td></td>
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<tr>
<td>Extension officer awareness</td>
<td>X ✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Extension program development</td>
<td>X ✓</td>
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<td>✓</td>
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<td>5.2 Extension &amp; information technology methods</td>
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<tr>
<td>Appointment of research student</td>
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<td></td>
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<td>Achieved prior to Yr.7</td>
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<tr>
<td>Baseline extension study</td>
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<tr>
<td>Subsequent studies</td>
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<td>✓</td>
<td>X ✓</td>
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</tr>
<tr>
<td>Evaluation of novel extension technology</td>
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<td></td>
<td></td>
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<tr>
<td>Appointment of post doctorate fellow</td>
<td>X ✓</td>
<td>X ✓</td>
<td>X ✓</td>
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<td></td>
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<tr>
<td>Comparison with existing techniques</td>
<td>X ✓</td>
<td>✓</td>
<td>X ✓</td>
<td>X ✓</td>
<td></td>
</tr>
<tr>
<td>5.3 Skills development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry education officer appointed</td>
<td></td>
<td></td>
<td></td>
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<td>Achieved prior to Yr.7</td>
</tr>
<tr>
<td>Training needs analysis completed</td>
<td></td>
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<td></td>
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<td>Achieved prior to Yr.7</td>
</tr>
<tr>
<td>Training courses developed for:</td>
<td></td>
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<td></td>
<td></td>
<td>Achieved prior to Yr.7</td>
</tr>
<tr>
<td>- production</td>
<td>X ✓</td>
<td>X ✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- industry</td>
<td>X ✓</td>
<td>X ✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- leadership</td>
<td>X ✓</td>
<td>X ✓</td>
<td>X ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>- facilitation</td>
<td>X ✓</td>
<td></td>
<td>X ✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Not attempted</td>
<td></td>
<td></td>
<td>X ✓</td>
<td></td>
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</tr>
<tr>
<td>Training courses run</td>
<td>X ✓</td>
<td>X ✓</td>
<td>X ✓</td>
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<td></td>
</tr>
<tr>
<td>Information officer appointed</td>
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<td>Achieved prior to Yr.7</td>
</tr>
<tr>
<td>Display material arranged</td>
<td>X ✓</td>
<td>X ✓</td>
<td>X ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>5.4 Professional development</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lecturers appointed:</td>
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<td>Achieved prior to Yr.7</td>
</tr>
<tr>
<td>- production</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Achieved prior to Yr.7</td>
</tr>
<tr>
<td>- cereals</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Students appointed</td>
<td>X ✓</td>
<td>X ✓</td>
<td>X ✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Tertiary courses developed and presented</td>
<td>X ✓</td>
<td>X ✓</td>
<td>X ✓</td>
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<td></td>
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<tr>
<td>Scholarship coordination</td>
<td>X ✓</td>
<td>X ✓</td>
<td>X ✓</td>
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<tr>
<td>Milestones for additional Year 8</td>
<td>Year 8 – 2004/2005</td>
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<tr>
<td>---------------------------------</td>
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<tr>
<td>Extension to the rice industry:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Coordination of extension program and the RGA Environmental Champion program to deliver CRC outcomes.</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Application of the aerial imagery program delivered to farmers and agribusiness through discussion groups, meetings and reports.</td>
<td>✔</td>
<td></td>
<td></td>
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<tr>
<td>Program 5301 skills development:</td>
<td></td>
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<tr>
<td>• Creation of course notes for on-going delivery of skills based courses beyond the life of the CRC.</td>
<td>✔</td>
<td></td>
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<tr>
<td>• Preparation of extension material to assist extension delivery.</td>
<td>✔</td>
<td></td>
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<tr>
<td>• Compile a rice publication resource centre.</td>
<td>Not completed</td>
<td></td>
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<tr>
<td>Program 5601 Communications:</td>
<td></td>
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<tr>
<td>• Communication of CRC results to industry groups and the local communities through providing opportunities for media events, field days, meetings and workshops.</td>
<td>✔</td>
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<tr>
<td>• Dissemination of CRC outcomes to the wider community through development of media opportunities.</td>
<td>✔</td>
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<tr>
<td>• Consolidation of a communication, image and website package to ensure longer-term availability of information beyond the life of the CRC.</td>
<td>✔</td>
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<tr>
<td>Program 5 postgraduates:</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>• Completion of all postgraduate programs</td>
<td>Will be achieved</td>
<td></td>
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<tr>
<td>• Provision of further workshop and training opportunities to add CRC value to postgraduate training.</td>
<td>✔</td>
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<tr>
<td>Community education:</td>
<td></td>
<td></td>
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<tr>
<td>• Development of education materials for school based rice specific education programs past the life of the CRC.</td>
<td>✔</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>• Interactive display at the CSIRO Discovery Centre.</td>
<td>✔</td>
<td></td>
<td></td>
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<tr>
<td>Tertiary education:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Produce further study material related to rice production and rice food processing to provide for education programs beyond life of the CRC.</td>
<td>✔</td>
<td></td>
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<tr>
<td>• Incorporate rice specific education into other University courses.</td>
<td>✔</td>
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<tr>
<td>• Evaluate the potential for summer and honours student opportunities post-CRC.</td>
<td>✔</td>
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</tr>
</tbody>
</table>

X = To be completed (in some cases this exercise is spread over several years).
✔ = Achieved (if not achieved, status provided.)

**NB:** After obtaining approval from the CRC Secretariat, comments on milestones for Years 1 to 3 inclusive have been removed from this table. Please refer to previous Rice CRC Annual Reports if you wish to view this information or contact the Rice CRC for additional information.
COLLABORATION

The Rice CRC sits within an existing network of research, development and service structures impacting on rice production and resource use in the southern irrigation areas. These groups include research, extension and education service providers, regulatory authorities, irrigation suppliers, community groups such as Land and Water Management Plan groups and industry organisations.

Strong links are important to ensure cooperation across all levels from natural resource use to marketing of end-product. The Rice CRC does not operate in isolation from either more applied research and development activities or the day-to-day operations of the industry. It is linked to the existing community and industry infrastructure in a way that aims to ensure a seamless two-way exchange between the theoretical and the practical application of technology.

Cooperative links have been fostered internally and with outside organisations within Australia and internationally. Some specific examples are provided to illustrate the extent of links developed through specific projects.

Project 1301 (The persistence of rice pesticides in floodwaters and how this is influenced by water management and layout) has collaborated with many groups to assist the development of the project, eg - Murrumbidgee Irrigation Ltd (water quality issues and research), Ricegrowers Association of Australia (Environment Officer regarding chemical management), RIRDC project participants (“Assessment of pesticide impacts on the biological health of the rice ecosystem”) and ongoing discussion with NSW Dept of Primary Industries staff and growers. Links have also been established with the CRC for Irrigation Futures and CRC for Catchment Hydrology.

The Glycaemic Index (GI) analyses for Project 4505 (Glycaemic index studies of rice) were undertaken on a commercial fee for service basis for SunRice by the Sydney University Glycaemic Index Research Service (SUGiRS). The GI testing is a specialised and time consuming task and SUGiRS are a world leading provider of GI using human subjects to test glycaemic response to foods.

Other linkages with non-CRC funded projects include:-

Project 1205 (Quantifying and maximising the benefits of crops after rice) has maintained strong international linkages through:-

* ongoing collaboration in with the DSSAT group (Decision Support Systems for Agrotechnology Transfer), a distributed group of international scientists developing the DSSAT/CERES crop modelling system, through Dr Jagadish Timsina at CSIRO Griffith;

* Dr Liz Humphreys as an Agreement Holder in the International Atomic Energy Agency Coordinated Research Project on “Integrated soil, water and nutrient management for sustainable rice-wheat cropping systems in Asia”. Through this project we are being supplied with 15N labelled fertilizer and soil and plant analyses for Project 1208.
* CSIRO Griffith as a member of the Rice-Wheat Consortium for the Indo-Gangetic Plains;

* collaboration by Liz Humphreys and Shahbaz Khan with IRRI and others writing a book chapter on Rice, Food and Water under the international “Comprehensive Assessment of Water Management in Agriculture” project led by the International Water Management Institute.

Newsletters

The Rice CRC has maintained its policy of producing an internal newsletter (Rice CiRCle) for CRC participants which is also distributed to non-CRC people with an interest in rice research, as well at its external newsletter “Rice Update” which is distributed to the majority of Australia’s rice growers courtesy of the distribution system established by SunRice. The Rice CRC also contributes to Ricegrowers’ Association of Australia’s electronic newsletter which is available on their website and is also distributed to its members electronically. The Rice CRC’s external newsletter is also available on its website.

International Projects

Participants from Project 1205 have continued to be involved in several international projects:-

* CSIRO Land and Water, NSW DPI and Punjab Agricultural University are collaborators in ACIAR project SMCN/2000/89 “Permanent beds for irrigated rice-wheat and alternative cropping systems in north west India and south east Australia”; and
* development of a new ACIAR project with collaboration between CSIRO Land and Water and Pakistan’s National Agricultural Research Council SMCN/2004/35 “Technology for direct drilling into rice and other heavy stubbles in Pakistan and Australia”.

CRC research into starch resistance (the proportion of starch that escapes digestion in the gut and travels through to the large intestine) in Sub-Program 4.5 (and related to glycaemic index studies in Project 4505) has increased its international linkages through the relocation of Dr Melissa Fitzgerald from NSW DPI at Yanco to IRRI in the Philippines. Two of her staff from Yanco have now also relocated to IRRI for a period of time to assist with research under her direct supervision. The resistant starch work is linked with PhilRice, the Philippine Government Rice research body, and with the Chinese National Rice Research Institute (CNRRI).

Visiting Scientists

Prof Sang-OK Chung is a Professor in Irrigation and Drainage Engineering, Department of Agricultural Engineering, Kyungpook National University, Taegu, South Korea. Prof Chung worked with participants in Project 1301 for six months, based at CSIRO Land & Water in Griffith, NSW.
As part of the CRC’s International Cold Tolerance Workshop in July 2005 held in Canberra, eight international scientists were sponsored to come to Australia and give presentations and exchange ideas. In particular, Dr Renata Pereira da Cruz (Instituto Rio Grandense do aroz, Cachoeirinha, Brazil) was invited to extend her visit to Australia to meet with CRC staff at Yanco Agricultural Institute and the University of Sydney.

In September 2004 the CRC also sponsored a visit by Prof Takeshi Horie (Kyoto University, Japan) who gave a presentation at the 4th International Crop Science Congress in Queensland, Australia and also took the time to meet with CRC staff at CSIRO Plant Industry in Canberra.

Professor Shahbaz Khan and team hosted a high level visit of Steering Committee members from the International Challenge Program on Water and Food to the Murray Irrigation Area (March 2005).

**Overseas Visits by CRC Staff**

In August 2004, a competitive grant from the Australia-Korea Foundation funded a visit to Gyeongsang National University in Jinju, Korea by Dr Ric Cother (NSW DPI) and Assoc Prof Gavin Ash (CSU) (Sub-Program 2.4). A survey of Alismataceae weeds in southern Korea was undertaken to obtain isolates of the fungus *Plectosporium tabacinum*, a potential biocontrol agent for several weeds in NSW rice crops. Prof Young Ryun Chung had organised visits to seven sites in southern Korea where *Sagittaria trifolia* was thought to occur. Unfortunately, typhoon activity restricted visits to only three sites. During these field inspections, the opportunity was taken to inspect rice crops for blast and bakanae, two exotic diseases of rice not present in Australia. Forty-five cultures of *Plectosporium*–like fungi were returned to Australia (under AQIS quarantine permits). Five isolates were tested for pathogenicity to *Alisma lanceolatum, Damasonium minus* and *Sagittaria graminea* but none were as virulent as local isolates from *A. lanceolatum*.

In July 2004 Sandra Oliver (PhD student) visited Berlin in Germany to present a poster at the International Conference on Arabidopsis Research.

In April 2005 David Allen (PhD student) visited Aarhus in Denmark and Atlanta in the USA to present papers at conferences in relation to his work in Project 1405.

Prof Shahbaz Khan visited the Global Impacts Studies Centre in Pakistan and presented a seminar on “Global climate change and water resources – Australian and Pakistan perspective” at the Global Climate Impacts Studies Centre - Islamabad, Pakistan, December 2004. Prof Khan presented a seminar on “Sustained Productivity of Degraded Land & Water Resources - A Catchment Approach” at the Pakistan Agricultural Research Council, Pakistan, December 2004.

Prof Khan trained scientists from Pakistan, Nepal and Bangladesh on linking climate with agricultural water management project at a workshop on watershed modelling held at Islamabad in March, 2005 under an Asia Pacific Network Project.

Prof Khan participated as an invited member of the National Meeting on Water for Food Model of the International Commission on Irrigation and Drainage in China, August 2004.
He also participated as an invited speaker with Mike Bonell (UNESCO, France) on the “Progress in the implementation of UNESCO IHP-HELP” at the international conference “Integrated Assessment of Water Resources and Global Change: A North-South Analysis”, Global Water System Project (GWSP) Bonn, Germany, February 2005.

Prof Khan presented a key note speech “Water Management Challenges for Irrigated Agriculture in Australia and Asia” at the International Conference on Water Security for Future Generations Changchun, Jilin Province, P.R. China, July 2004.

Prof Khan visited DuPont in USA and made a combined presentation (led by Dr Annabelle Duncan, Chief CSIRO, Molecular Science) to DuPont fellows, participated in two round table discussions on water and food and water technologies areas and gave a plenary seminar presentation.

Liz Humphreys, Jagadish Timsina, John Blackwell, Geoff Beecher, John Thompson, Darryl Gibbs and Nick Ellwood participated in the ACIAR project mid-term review in India in September 2004.

Liz Humphreys visited India and Pakistan in February 2005 to review ACIAR project progress at PAU in India and to progress project planning in Pakistan. In February Dr Humphreys also participated in the 13th Technical Coordination Committee Meeting of the Rice-Wheat Consortium for the Indo-Gangetic Plains in Dhaka, Bangladesh.

Liz Humphreys reviewed ACIAR project SMCN/1999/005 “Improved soil management of rainfed vertisols in West Nusa Tenggara” in Indonesia in November 2004.

Melissa Fitzgerald is leading research on resistant starch (Sub-Program 4.5). She was formerly with NSW DPI and is currently located with IRRI in the Philippines. Dr Fitzgerald will visit Australia (SunRice and NSW DPI) in June 2005 and give a presentation on her work in relation to CRC Projects 4505/4505.

(See also “Public Presentations, Public Relations and Communication”)

The following table identifies linkages established within Rice CRC projects.

<table>
<thead>
<tr>
<th>Project No.</th>
<th>Chief Investigators</th>
<th>Linkages</th>
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<tbody>
<tr>
<td>1105</td>
<td>CSIRO Land and Water</td>
<td>NSW DPI</td>
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<td>Charles Sturt University</td>
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<td></td>
<td></td>
<td>CICL</td>
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<td>CSIRO Plant Industry</td>
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<td></td>
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<td>CSIRO Earth Observation Centre</td>
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<td>1107</td>
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<td>Irrigation companies</td>
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<td>Pratt Water Group</td>
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<tr>
<td>1204</td>
<td>NSW DPI</td>
<td>CSIRO Land and Water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Charles Sturt University (CSU)</td>
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<tr>
<td>Project No.</td>
<td>Chief Investigators</td>
<td>Linkages</td>
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</tr>
</tbody>
</table>
| 1205       | CSIRO Land and Water| Project 1208  
NSW DPI  
DSSAT group  
IAEA  
IRRI  
Rice-Wheat Consortium for Indo-Gangetic Plains  
ACIAR  
Punjab Agricultural University |
| 1207       | CSIRO Land and Water| Rice CRC Sub-Programs 1.1, 1.2 and 1.4 (Projects 1205, 1204 and 1403) |
| 1301       | CSIRO Land and Water| Murrumbidgee Irrigation Ltd  
Ricegrowers’ Association of Australia  
RIRDC  
NSW Dept Primary Industries  
CRC for Irrigation Futures  
CRC for Catchment Hydrology |
| 1302       | Charles Sturt University| CSIRO Land and Water, Griffith |
| 1304       | CSIRO Entomology| CSU  
Cotton Research & Development Corporation  
Australian Cotton CRC  
Horticulture Australia Ltd  
Orica Australia Limited  
Prof Alan Devonshire, formerly IACR-Rothamsted, England |
| 1404       | CSIRO Land and Water| Murrumbidgee Irrigation Limited  
Murray Irrigation Limited  
CICL  
NSW DPI  
Pratt water project  
CSIRO’s Water for a Healthy Country flagship program  
Catchment Management Authority |
| 1405       | University of Technology Sydney| Geo-Force, Perth  
DIPNR  
Zonge Engineering & Research  
CICL  
Aarhus University Hydrogeophysics Group, Denmark |
| 2201       | NSW DPI| University of Queensland, linked to cold group  
Hokkaido University, Japan  
CSIRO Plant Industry |
| 2206       | NSW DPI| University of Queensland |
| 2302       | NSW DPI| CSU  
Yezin Agricultural University, Myanmar and Central Agricultural Research Institute. |
<p>| 2408       | Charles Sturt University| Murray-Darling Basin Commission |
| 2409       | Charles Sturt University| NSW DPI |</p>
<table>
<thead>
<tr>
<th>Project No.</th>
<th>Chief Investigators</th>
<th>Linkages</th>
</tr>
</thead>
<tbody>
<tr>
<td>3201, 3208 &amp; 3209</td>
<td>CSIRO Plant Industry</td>
<td>Dr Deep Saini (Montreal), linked to cold group CSU NSW DPI University of Sydney Institut de recherché en biologie vegetale, University of Montreal, Canada Max-Planck-Institute for Molecular Plant Physiology, Golm, Germany</td>
</tr>
<tr>
<td>3202, 3202(a) &amp; 3202(b) /3211</td>
<td>The University of Sydney</td>
<td>NSW DPI CSIRO Plant Industry (linked to cold group)</td>
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<td>3203</td>
<td>CSIRO Entomology CSIRO Plant Industry</td>
<td>NSW DPI</td>
</tr>
<tr>
<td>3301</td>
<td>The University of Sydney</td>
<td>NSW DPI Rice Research Institute, Yunnan Agricultural University, China International Centre for Tropical Agriculture, Columbia CSIRO Plant Industry, Canberra</td>
</tr>
<tr>
<td>3404</td>
<td>University of Sydney</td>
<td>Project 3402 Project 3405 NSW DPI CSIRO Plant Industry</td>
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<tr>
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<td>Project 3402 Project 3404 NSW DPI CSIRO Plant Industry</td>
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<tr>
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<td>CSIRO Stored Grains Research Laboratory NSW DPI GasApps Australia</td>
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<tr>
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<td>CSIRO Stored Grains Research Laboratory University of Technology Sydney</td>
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<tr>
<td>4303</td>
<td>SunRice</td>
<td>CSIRO Stored Grains Research Laboratory</td>
</tr>
<tr>
<td>4501</td>
<td>The University of Sydney SunRice</td>
<td>NSW DPI Charles Sturt University</td>
</tr>
<tr>
<td>4504 /4505</td>
<td>SunRice NSW DPI/IRRI Philippines</td>
<td>PhilRice University of Sydney Chinese National Rice Research Institute</td>
</tr>
<tr>
<td>5101</td>
<td>NSW DPI</td>
<td>CRC participants, particularly SunRice Rice growers Terrabyte Services Agribusiness</td>
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<td>5204</td>
<td>Charles Sturt University</td>
<td>CICL Ricegrowers’ Association of Australia NSW DPI</td>
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<td>5301</td>
<td>NSW DPI</td>
<td>Links to education SunRice</td>
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<tr>
<td>Project No.</td>
<td>Chief Investigators</td>
<td>Linkages</td>
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<tr>
<td>5302</td>
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<td></td>
<td>Various infants and primary schools</td>
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<td>Leeton Visitors’ Centre</td>
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<td>CSIRO Discovery Centre</td>
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<td>5401</td>
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<td>NSW DPI</td>
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<td>CSU</td>
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<td>5601</td>
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<td>Metropolitan and regional media</td>
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</table>

See Part D for remainder of Report