

PROGRAM 3 GENETIC IMPROVEMENT FOR SUSTAINABLE PRODUCTION

Program Leader:

Dr Liz Dennis
CSIRO Plant Industry
Canberra

Program 3 aims to contribute to the sustainability of rice in Australia through targeted genetic and grain quality research.

Specific objectives are:

- * improved yield efficiency through increased yield and reduced growth duration;
- * improved tolerance to the abiotic stresses of cold and salinity;
- * improved genetically controlled competitiveness with weeds and insects;
- * improved breeding techniques; and
- * increased understanding of key quality attributes – particularly those controlled by endosperm starch structure.

3.1 Improved Yield Efficiency

Sub-Program Leader:

Dr Laurie Lewin and Mr Russell Reinke
NSW Agriculture
Yanco

Improved yield efficiency can be achieved through increased yield, reduced duration or a combination of both. This would improve both economic performance and water use efficiency.

Improved yield efficiency (3101)

Project Leader:

Dr Laurie Lewin, Mr Russell Reinke and Mr Peter Snell
NSW Agriculture
Yanco

- * *Short duration rice*

Lines of shorter duration have been introduced from Russia and Hungary. Preliminary results indicate that they have real potential as parents but not directly as varieties. Twenty-two crosses have been made to combine the short duration with high yield and quality attributes.

- * *Hybrid rice*

There is potential to improve yield through production of hybrid rice. More than 40% of the rice area in China is now planted with hybrid varieties and the hybrid rice area is increasing in

other Asian countries. While hybrid vigour is greater in “indica” (tropical) rice varieties than in the “japonica” (temperate) types grown in Australia, there are potential yield increases of 15% to 20%. Appropriate male sterility systems are a prerequisite for hybrid rice development.

Eleven cytoplasmic and seven thermosensitive male sterile lines have been introduced from IRRI. They are being used to create adapted male sterile systems for hybrid seed production.

* *Evaluation of tropical japonica germplasm (super rices)*

It is thought that tropical japonica varieties may increase tropical rice yield by more than 20%. First generation tropical japonica varieties (super rices) from IRRI, when grown in Australia, have exhibited some of the improved characteristics but long duration and cold sensitivity affected yield potential. Yields were below those of current commercial cultivars.

New indirect selection techniques for improving rice yield potential (3102)

Project Leader:

Dr Tony Condon
CSIRO Plant Industry
Canberra

There is strong evidence, from previous work with rice and ongoing work with wheat, that physiological traits related to stomatal aperture may prove effective in screening rice breeding lines for yield potential.

This project aims to determine:-

- * whether variation in stomatal aperture-related traits (SATs) is present within advanced breeding lines being evaluated by the NSW Agriculture rice breeding program at Yanco;
- * effective ways to combine SATs to obtain the most useful data for the least cost; and
- * whether SATs can be used on short rows as well as small plot trials.

Substantial genotypic variation in stomatal conductance was found within the rice germplasm tested. Variation in stomatal conductance was correlated with canopy temperature measured using hand-held devices. These relationships were observed for measurements on small-plot trials and also for measurements on short rows. At the time of reporting, variation in canopy temperature captured with thermal imagery was still being assessed, as was variation in stable isotope composition of oxygen and carbon in plant tissue.

3.2 Tolerance to abiotic and biotic stress

Sub-Program Leader:

Dr Liz Dennis
CSIRO Plant Industry
Canberra

A combination of biotechnology, traditional selection methods and varying growth conditions are being used to investigate improved rice sustainability through enhanced resistance to

biotic and abiotic stress. Attack by bloodworm and competition from weeds are the biotic stresses being examined and cold conditions during pollen formation is an example of abiotic stress. The cold tolerance project is closely linked to work proceeding in Program 2. By taking complementary approaches to these major problems advances in our understanding will be made.

Molecular basis of cold tolerance (3201); Molecular mechanisms of cold stress (3204)

Project Leader:

Dr Liz Dennis
CSIRO Plant Industry
Canberra

These projects aim to understand the influence of cold on developing rice pollen by:-

- * studying the effect of cold on carbohydrate metabolism in anthers. Cold stress leads to accumulation of sucrose early after meiosis and a depletion of starch granules in mature pollen. We will clone anther-specific genes encoding apoplastic invertase, an enzyme essential in downloading sugar in anther tissues, and study the effect of cold on the expression of these genes;
- * studying the effect of expressing the yeast apoplastic invertase gene in rice anthers on cold-tolerance of rice pollen;
- * investigating the role of increased boron levels in pollen on fertility during cold conditions. This will be achieved by over-expressing sorbitol dehydrogenase in rice. Increased levels of the polyol sorbitol have been shown to lead to increased boron levels in plant tissues and this could potentially lead to improved fertility after cold treatment; and
- * constructing cDNA libraries from anther tissue grown under normal and cold temperature conditions. This will allow us to identify gene products that are specifically affected by cold conditions.

Progress

Growth and cold-treatment conditions have been established for the cold-sensitive rice variety Doongara. Large quantities of anther material were sampled at the tetrad stage. This material will be indispensable to start the molecular analysis of invertase gene expression and the construction of cDNA libraries.

Three rice invertase genes (*OSINVI,2,3*) have been cloned and sequenced using rice cDNAs from the EST library. Two of these genes encode the insoluble or apoplastic form of acid invertase, while the third gene is more related to soluble cytosolic invertase. These genes were used to isolate more genomic clones by low stringency screening of a genomic library. These clones are currently being examined. This *OSINVI* gene is expressed in anther tissue

The construction of the yeast apoplastic invertase construct for transformation to rice has been started. Suitable rice promoters to drive expression of this construct in the tapetum and pollen cells have been identified.

A construct with the apple sorbitol dehydrogenase gene driven by the strong ubiquitin promoter has been completed and is ready for transformation to rice. Construction of promoter-reporter gene constructs using the promoter of one of the apoplastic invertase genes has commenced. This gene (*OSINVI*) is expressed in anther tissues.

Cellular reaction to cold (2203/2204/3202)

Project Leader:

Dr Bruce Sutton
University of Sydney
Sydney

(Refer to Report provided in Program 2)

Bloodworm resistance (3203)

Project Leader:

Dr Liz Dennis
CSIRO Plant Industry
Canberra

The aim of the project is to develop rice varieties resistant to bloodworm (*Chironomus tepperi*). This should lead to decreased use of pesticides during rice establishment.

Progress

A Postdoctoral Fellow has been appointed commencing August 1999. Collaboration between CSIRO Plant Industry, CSIRO Entomology and NSW Agriculture (Yanco) has been established. A literature survey has been completed and the research plan formulated.

Rice bloodworm is a major pest at the time of rice establishment. All aerial sown crops are treated with insecticide at least once to control the pest. While not an expensive treatment, the possibility of water contamination cannot be eliminated. Development of resistant genotypes has been the subject of a project funded through RIRDC. While there were apparent differences in resistance to attack, no cultivar was sufficiently tolerant to avoid chemical application. This project will evaluate the potential to develop resistance through biotechnology.

Allelopathy and weed competition (3205)

Project Leader:

Prof Jim Pratley
Charles Sturt University
Wagga Wagga

Allelopathy is the ability of one plant (rice) to suppress the growth of another (weeds). Evidence of allelopathy in some rice varieties has been obtained in some rice producing areas, including the USA and the Philippines.

The aims of this project are to:-

- * determine the allelopathic capability of current varieties and other germplasm to provide control of weeds of Australian rice crops;
- * identify and quantify the phytotoxins involved;
- * evaluate the individual toxins individually and collectively for development as natural herbicides; and
- * evaluate the potential for incorporating allelopathy into crop varieties.

Progress

The project required the appointment of a PhD student. Ms Alexa Seal was appointed from Canada to the position and commenced her studies in November 1998. Since that time she has visited Dr Dilday's laboratories in the United States, undertaken an extensive literature search on the project and has selected and processed for import the germplasm needed to undertake the research. A range of screening procedures are being evaluated to ensure that the project aims can be efficiently addressed.

Salt tolerance

Project Leader:

Mr David Troidahl
NSW Agriculture
Yanco

Salinity tolerance is not normally required in Australian rice growing. It would be useful, however, where rice is to be used to reclaim salt affected areas, where water is used from saline underground water or where salt accumulates temporarily in bays.

The aim of the project is to measure the responses of NSW commercial rice cultivars to salinity and to devise selection strategies to ensure that cultivars of the future have adequate tolerance.

Five NSW commercial cultivars were compared for tolerance to salinity with Pokkali, a known tolerant variety. No NSW cultivar appeared to be as tolerant as Pokkali. The medium grain cultivars - Amaroo, Jarrah and Millin were more tolerant than long grain Pelde and Langi.

Trials have also commenced to test a wider range of commercial cultivars under standard test conditions and to extend the test to cover the complete growth cycle for rice cultivars under evaluation. First crosses to include tolerance into commercial background have been made.

3.3 Enhancing the technology base for rice improvement

Sub-Program Leader:

Dr Norm Darvey
University of Sydney
Cobbitty

The original objective of this Sub-Program was to develop an isolated microspore culture system for rice. This project was initiated by Dr Xiaochun Zhao with the assistance of a Masters coursework student in Plant Breeding, Ms Xiao Bo Lu. In 1999 this work will be continued by a postgraduate student as part of the approved project.

A second objective aimed at developing a standardised system for controlled experiments on cold tolerance in rice was given a high priority and work on this project was initiated by Dr Xiaochun Zhao in 1998.

Microspore and spikelet culture in rice (3301)

Project Leader:

Dr Norm Darvey
University of Sydney
Cobbitty

** Microspore culture*

Anther culture is a routine component in many rice improvement programs but low regeneration rates limit its value. Each anther is made up of many microspores and culture of these has the potential to significantly increase the number of plants per culture and improve the economic potential of the technique.

The aims of the project are to:-

- * recover haploids via microspore culture (MC);
- * apply MC technology to interspecifics carrying genes for economic characters; and
- * apply MC technology to materials from national breeding program.

Progress

Six NSW cultivars were tested for their induction response to anther culture. All lines produced callus, with three lines producing good levels of callus production (20% callus production per 100 anthers plated). Anti-apoptotic compounds (ATA) are being evaluated for their effect on culture response. No satisfactory pre-culture medium for isolated microspores has been determined to date, however successful pre-culture in mannitol has recently been described by Raina and Irfan (1998. Plant Cell Reports 17: 957-962) for both *japonica* and *indica* rices.

* *In vivo and in vitro culture of rice for controlled experimentation into cold tolerance*

Spikelet culture is not necessarily of direct value in breeding programs but could be manipulated in studies of spikelet development. This would be particularly useful in studies of cold tolerance in rice.

The project has many objectives, including:-

- * development of a rapid clonal propagation system *in vivo*;
- * development of a plant propagation system *in vitro*;
- * development of a panicle culture system *in vitro*;
- * development of a spikelet/floret/sub-floret culture system *in vitro*;
- * experimentation on cold tolerance using the above systems; and
- * molecular genetic studies into cold tolerance using the above systems
 - seeking molecular marker for cold tolerance eg. omega unsaturase gene
 - mRNA differential display technique.

Progress

Large numbers of panicles have been generated in a locally constructed hydroponic system. Mini-hydroponic units with individual sodium lights are being constructed for controlled experiments under various temperature regimes to confirm the critical stage for cold damage on pollen development.

Young detached panicles were cultured on various media. Panicles at the mid-uninucleate stage grew to almost full length but failed to develop further. This work is continuing with studies on media and growth regulator variations. Some of the growth regulators showed improvement in spikelet and glume development but none of them resulted in normally developed anthers (Table 2).

Table 2: Comparison of spikelet development *in vitro* in liquid media containing different combinations of plant growth regulators*

Constituent of medium (mg/l)			Development of spikelet	Development of glume	Development of anther
IAA	BAP	GA ₃			
0	0	0	Near-normal	Abnormal-Slow	Failed
10			Normal	Normal	Failed
10	5		Normal	Near-normal	Failed
10		2	Abnormal	Failed	Failed
		4	Abnormal	Failed	Failed

* Incubated 10 days at 26°C with lights. Development of spikelets and glumes *in vitro* was compared to that in normally growing plants.

Detached floret organs were also cultured in liquid media. There was apparent normal development of the anthers *in vitro* during the critical period where cold damage is thought to be greatest.

* *Molecular genetics research*

There is an emerging interface between the cellular biology and molecular biology research.

A primer has been designed for omega unsaturase in rice. Omega unsaturase genes have been linked to cold tolerance in general. Polymorphism for this marker has been identified among Australian rice cultivars.

Work has commenced on identifying mRNA that is related to cold tolerance. This will potentially identify those genes which are involved in cold tolerance.

Work has also commenced on enzymatic and immunochemical analysis of beta-glucanase. This enzyme is involved in the modification of cell wall components. The activity of beta-glucanase in the anther is related to premature callose degradation and early appearance of this enzyme may lead to cytoplasmic male sterility. Analysis of the enzymes could detect its activity in response to a cold treatment.

3.4 Breeding for quality attributes

Sub-Program Leader:

Mr Tony Blakeney
BRI Australia Ltd
Sydney

The quality attributes of rice include physical descriptors of the milled white grains and characteristics of the cooking quality of rice. In this Sub-Program research is addressing three quality attributes that are difficult to measure and to breed for:-

- * suncracking;
- * amylose structure; and
- * heritability and expression of isoforms of the genes of starch synthesis.

The problem of cracked grain reduces both yield and quality. Cracked grains tend to break during milling, which decreases milling yield and those that do not break detract from the physical appearance of the rice. It is difficult to breed for because environmental conditions greatly influence cracking.

Cooking quality is difficult to breed for since we don't fully understand the factors that influence it. The findings of the projects on amylose structure and on the isoforms of the genes of starch synthesis will contribute to our understanding of cooking quality and our capacity to breed rices that contain the quality attributes that markets desire.

Understanding the effects of starch synthesis on suncracking and chalk (3401)

Project Leader:

Dr Melissa Fitzgerald
NSW Agriculture
Yanco

The aims of this project are to:-

- * identify whether cracked grains differ physically or chemically from whole grains;
- * investigate the biochemical/physiological mechanism that increases the susceptibility of varieties to cracking; and
- * carry out work to assist in developing a molecular marker strategy to allow the identification of varieties that are susceptible to cracking.

Progress

Ms Stephanie Vaughan (PhD student) has been appointed and commenced work on 22 February 1999. Her work is supervised by Dr Melissa Fitzgerald (NSW Agriculture) and Dr Chris Blanchard (Charles Sturt University).

The protein complement and the starch structure of cracked grains differs from those of whole grains. Furthermore, lines tolerant to cracking differ from those lines susceptible to cracking. This result is very encouraging because it indicates that cracking is not solely due to uncontrollable environmental events, but that there is a genetic component which, in time, we hope to identify and use to develop molecular marker strategies.

Previous work has been confirmed that shows that when the grain experiences moisture cycles that repeatedly toggle above and below 23%, the percentage of cracked grain is six-fold greater than when the moisture content of the grain is maintained below 18%. This is most likely due to the effect of water upon the crystalline properties of the starch. Investigations are continuing.

Understanding amylose structure: what it controls and what controls it (3402)

Project Leader:

Dr Melissa Fitzgerald
NSW Agriculture
Yanco

This project is scheduled to commence in July 1999. It will be an important component of the total program on quality in rice and will link to the other components of the Sub-Program. It aims to:-

- * develop a method to measure the structure of amylose chains;
- * determine the effect of amylose structure on the swelling and gelation of starch granules;
- * determine the effect of amylose structure on the texture of the gel in cooked rice;
- * understand the effect of amylose structure on the texture of retrograded gel in cooked, cool rice grains; and
- * elucidate some of the factors that control amylose structure at the genetic level.

Investigation of the effect of genetic variation on rice quality (3403)

Project Leader:

Dr Christopher Blanchard
Charles Sturt University
Wagga Wagga

This project complements the previous one but is directed more at genetic control of quality attributes. The aims of this project are to:-

- * establish a molecular biology laboratory;
- * search the literature to determine what variations in starch synthesis genes have been identified in Australian and overseas cultivars;
- * identify possible effects these variations may have on rice quality; and
- * develop strategies for identifying these variations and assessing the effect on rice quality.

Progress

Mr Andrew Eamens (PhD student) was appointed to the project and commenced in April 1999. He commenced a search of the literature to familiarise himself with previous research on variations between starch synthesis gene alleles. In his literature review he identified research in the USA which describes a temperature sensitive granule bound starch synthase mutant in USA cultivars which affects amylose content. Mr Eamens has designed a novel strategy to quickly and easily determine if this mutation is present in Australian cultivars.

MILESTONES

	Milestone	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
3.1	Improved Yield Efficiency							
	Appointment of Assistant	X Deferred	Deferred					
	Introduction of male sterile lines	X ✓	X ✓	X				
	Evaluation of Hybrid Lines		X Commenced	X	X			
	Evaluation of tropical japonica lines	X ✓	X ✓	X				
	Development and evaluation of inducible male sterility		X RIRDC project	X				
	Evaluation of available apomictic systems		X RIRDC project	X	X	X	X	X
	Incorporation of improved yield traits		X Commenced	X	X	X	X	X
3.2	Stress Tolerance							
	Cold scientist appointed	X ✓						
	- develop assay methods for pollen sterility	X ✓						
	- ABA assay	X Developed						
	- potential genes isolated	X ✓	X ✓					
	- insert and test useful constructs		X Commenced	X	X			
	- student project commenced	X ✓	X ✓	X	X			
	- genes incorporated from Zinania		X RIRDC project	X				
	Bloodworm resistance							
	- Feasibility investigated	X Commenced	X Partially achieved (see report for 3.2)					
	Allelopathy							
	- student appointed	X Deferred	✓					
	- varieties introduced	X Commenced	X Partly achieved					
	- mechanics studied	X Deferred	X Deferred	X	X			
	- characters incorporated				X	X	X	X
	Salt tolerance							
	- commercial varieties evaluated	X ✓	X ✓					
	- resistance incorporated		X Commenced	X	X	X	X	X
3.3	Breeding Methods							
	Isolated microspore culture							
	- conditions optimised	X Partially achieved						
	- optimise response	X Partially achieved	X Commenced	X				
	- evaluate cultivar response		X Commenced	X	X			
	- doubled haploid production		X Not Achieved	X	X	X	X	X
	- extension of technique					X	X	X
	Development of markers for semi-dwarf and fragrance		X RIRDC project	X	X			
	Extension of markets to other traits					X	X	X
	Development of male sterility				X	X	X	X

	Milestone	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
3.4	Breeding for quality attributes							
	Appointment of Research officer, PhD Student		X ✓					
	Appointment of a Technical Officer		X ✓					
	Evaluate factors promoting chalkiness	Promoted from year 2 to year 1	X Transferred to RIRDC	X	X			
	Evaluate factors promoting suncracking		X Commenced	X	X			
	Evaluate novel quality characteristics	X Waxy gene evaluated	X Commenced	X	X	X	X	X

X = Year due for completion (in some cases this exercise is repeated over several years).

✓ = Achieved (if not achieved, status provided)

PROGRAM 4

PRODUCT AND PROCESS DEVELOPMENT

Program Leader:

Mr Graeme Marteene
Ricegrowers' Co-operative Limited
Leeton

Challenges to the Australian rice industries over the past 12 months have seen significant changes to expectations of rice commodities and increased pressure caused by aggressive competition into Ricegrowers' Co-operative Limited's traditional markets. Quality standards and food safety have become a significant criteria for the sustainability of the industry. Program 4 is focused on addressing these challenges specifically on three fronts, these being - Quality Systems and Food Safety, Processing and Technology advancement, and new product innovation for diversification of the commodity business.

4.1 Grain quality in the pre-milling phase

Sub-Program Leader:

Mr Rod Bowman
Ricegrowers' Co-operative Limited
Leeton

Drying of the initial rice paddy and subsequent storage is critical to the quality of the milled rice. Drying occurs to remove excess moisture from a nominal 22-24% to 14-15%. Storage quality is maintained by aeration of the storage bins, which controls moisture and grain temperature. Unwanted trash (straw, chaff, flatheads etc) affects aeration patterns allowing inconsistent control of temperature and moisture, which results in deteriorating quality. Development of a trash monitoring system is being developed using the "Kice" and "Model S" equipment which evaluate incoming trash levels. Results to date have been inconsistent and correlation has been poor.

The second part of this Sub-Program is to develop an objective quality assurance method for Paddy Rice Appraisals using the "GrainCheck Image Analyser". This has been successful with a reproducible method being identified and is currently being evaluated within the RCL operation.

Grain quality in the pre-milling phase (4101)

Project Leader:

Mr Rod Bowman
Ricegrowers' Co-operative Limited
Leeton

This project is currently made up of two components. These are:-

* *Development of objective methods of quality assurance (Mr Nathan Cutter)*

Traditionally quality assurance in the rice industry has relied on the use of subjective analysis. The time consuming, labour intensive and skilled task of hand appraisal has been used for quality assurance in the absence of a more accurate method. However, hand picking for quality assurance is subject to problems. Eyestrain and fatigue can alter a technician's perception of a sample.

Within the industry there are many quality assurance technicians and each has the potential to develop their own perception of quality parameters. This is deleterious to the production of a high quality product.

This project aims to develop an objective appraisal system to standardise measurement across all samples.

Progress

A GrainCheck 310[®] image analysis instrument has been purchased to facilitate this task. This has been successfully used to accurately determine the broken rice content of samples and work has commenced to accurately predict chalk levels.

* *Trash determination at point of receipt (Mr Nathan Cutter and Ms Nicole McQuillan)*

Excessive trash (including straw, chaff, flatheads etc.) in rice as it is delivered causes delays in the intake pit, unloading and cleaning. It also wastes storage capacity. Better understanding of the trash levels will improve management of the crop.

This project aims to:-

- * assess the feasibility of accurately defining trash levels using a standard hull weight or brown rice weight;
- * ensure readings correlate with standard RCL method of trash determination; and
- * determine feasibility of process being introduced to each receipt site.

Progress

Two trash measurement devices – Kice[®] aspirator and Rationel Kornservice Model S[®] were compared with the industry standard, Carter Day Dockage Tester[®]. They correlated poorly with this standard. This has resulted in recommendations for improved measurement in the 1999 harvest and these results are now being assessed.

4.2 Development of rice milling in-line process control (4201)

Sub-Program Leader:

Mr Scott Brindley
Ricegrowers' Co-operative Limited
Leeton

This project aims to develop systems to accurately monitor rice processing (milling). Markets are becoming increasingly aware of processing characteristics such as crack development, temperature gradients developed during milling and degree of milling.

Progress

Software has been developed to collect quality and processing data through processing and packaging. This is linked to processing components and the moisture meter. This software is currently being trialed at Deniliquin Mill.

A mathematical model to represent the “whitening process” (removal of bran layer from brown rice) has been completed. It is currently being trialed to confirm its ability to predict grain quality. Once fully developed, the model will be used to devise control strategies.

The first stage of this process has been to develop operational parameters, measurement procedures and the effect of rice variety on the milling process.

The model has been shown to accurately predict the degree of milling, percentage of broken grain and temperature rise across the whiteners under a wide range of operating conditions and for the long and medium grain varieties tested.

The model also proved to be useful for determining the optimum settings of motor loads to give the desired degree of milling, whilst minimising the percentage of broken grain and temperature rise across the whiteners.

4.3 Quality assurance systems and post-harvest pest management (4301)

Sub-Program Leader:

Ms Robyn Delves
Ricegrowers' Co-operative Limited
Leeton

The Australian rice industry must continue to meet customers' quality expectations, both domestically and internationally. This Sub-Program focuses on:-

- * Integrated Pest Management, and
- * Food Safety

Emphasis has been placed on the development of insect control strategies that will replace methyl bromide fumigation.

** Microwave heating of paddy rice*

This was trialed on a small scale and successfully killed all life cycle stages of insects with minimal damage to the grain. There was a minor loss of milling yield (1 - 2%) with no deterioration in colour or eating quality.

Other physical methods being investigated include the heating of paddy rice by conductive heat and the cooling of both paddy and finished product to sub zero temperatures for

disinfestation. The parameters which give the most rapid kill while maintaining grain quality need to be firmly established.

Chemical alternatives to methyl bromide have been investigated. The potential alternatives include:-

* *Ethyl formate*

This chemical alternative is being studied in cooperation with the CSIRO Stored Grains Research Laboratory.

* *CO₂ fumigation*

Preliminary studies indicated that this method is not likely to provide an economic pest control alternative.

* *Phosphine fumigation*

Preliminary analysis also indicated that this method is unlikely to be successful.

* *Carbonyl sulphide*

This alternative will be investigated in conjunction with the CSIRO Stored Grains Research Laboratory.

4.4 Novel applications for value-adding rice hulls (4401)

Sub-Program Leader:

Mr Peter Klatt
Ricegrowers' Co-operative Limited
Leeton

Around 220,000 tonnes of rice hulls are a by-product of rice milling annually. No cost-effective beneficial use is available for over half of this tonnage.

One alternative is the use of hulls as a stock food but low digestible energy content has always limited hull use as a food product.

Enzymatic treatment of rice hulls to produce higher digestibility has been completed. This involved carrying out a number of trials using the following processes:-

- * grinding;
- * use of 'caustic' treatment; and
- * use of enzymes.

There was a 10-20% increase in digestibility with grinding and "caustic" treatment. There was also an apparent increase in digestibility with enzyme use but these differences were not statistically significant.

Figure 7

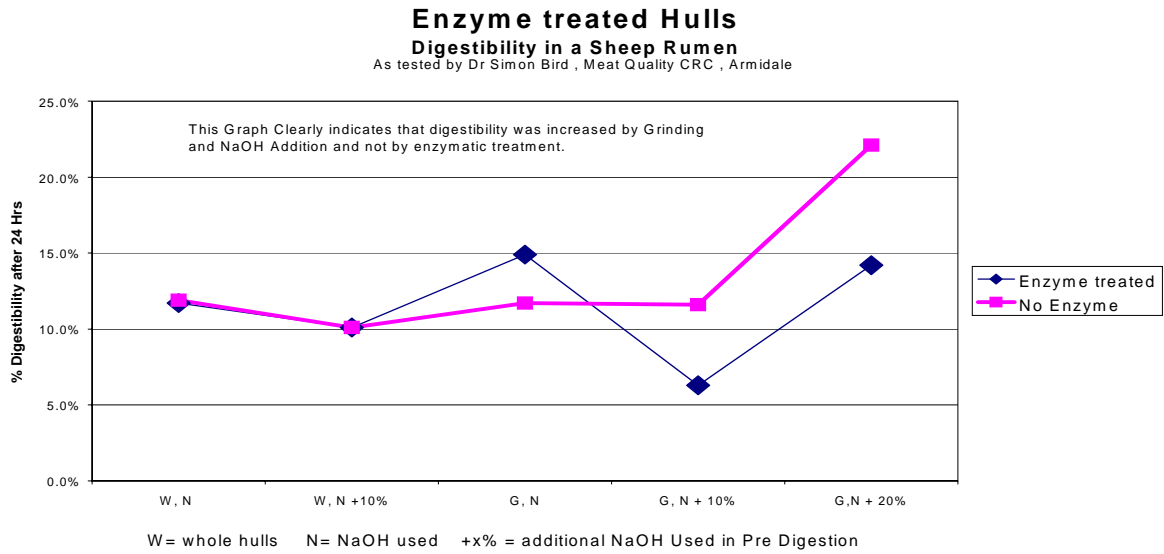
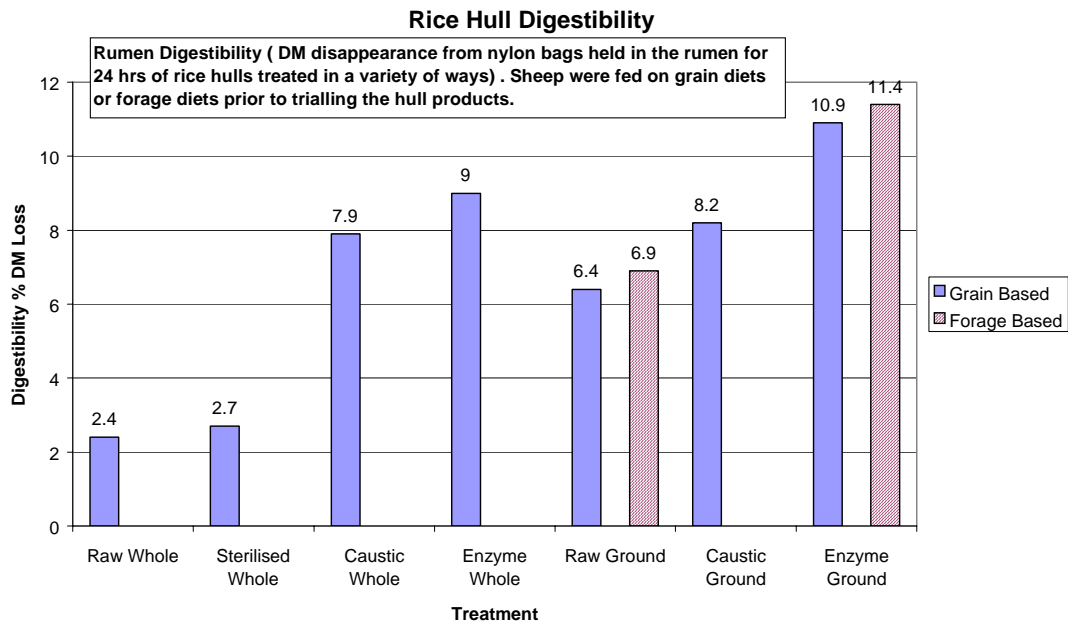


Figure 8



Enzyme or caustic treatment of hulls is unlikely to be an economic proposition for utilisation. The use of hulls as a replacement for timber dunnage is still being investigated.

4.5 New rice-based foods (4501)

Sub-Program Leader:

Mr Phillip Williams
Ricegrowers' Co-operative Limited
Leeton

The Australian rice industry always seeks to add value to its products prior to sale. To date, however, there has been limited additional value adding. New products could enhance returns to the industry through increased processing. This sub-project has examined a number of potential processes.

** Quick cooking rice*

Substantial progress has been achieved in this project. Variables such as variety and processing conditions, which have an impact on factors such as rehydration, have been studied. Improved methods of quantitatively assessing these changes are required and new methods are being developed.

** Rice noodles*

The suitability of existing rice varieties for rice noodle production is being assessed. This project will also evaluate rice flours and rice flour mixes for noodle production. Methods of production and assessment of rice noodles are required for this project. This stage of work is proceeding.

** Waxy rice flour*

Production of waxy rice flour was investigated as it has potential for a range of new products. The project indicated that improved milling capability would be required for the rice industry to produce a waxy flour of consistent quality. The industry has decided, however, that the market would not be of sufficient value to compensate for the additional difficulty of segregating waxy rice. This project has been discontinued.

Development of new vitamin and mineral fortification technique for rice (4502)

Project Leader:

Mr Phillip Williams
Ricegrowers' Co-operative Limited
Leeton

Folic acid is currently not added to any vitamin enrichment mixes produced by the Australian rice industry due to the distinctive yellow colour imparted on the premix. New methods of enriching rice have been developed to overcome this technical difficulty. Colour of the enriched rice as well as vitamin stability and adhesion of the vitamin to the rice are key technical issues. Laboratory scale trials have shown promise and larger production trials are being evaluated. In addition, methods of assessing the impact on changed colour are being developed.

MILESTONES

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
4.1	Grain Quality in the pre-milling phase							
	Appointment of Scientific officer	X Consultants used						
	Sampling procedures optimised.	X Commenced	X ✓					
	Individual grain moisture distributions monitored	X Commenced	X ✓	X				
	Optimum grain drying strategies developed		X Commenced	X	X	X		
	Training programs developed		X Deferred	X	X			
	Training programs implemented			X	X	X	X	X
4.2	Development of rice handling in-line process control							
	Software development	X Commenced	X ✓					
	Closed loop control developed for degree of milling/whitening		X Commenced	X				
	Moisture meter interface developed	X ✓	X ✓					
	Packer weigher interface developed	X ✓	X ✓					
	Process weigher interface developed	X ✓	X ✓					
	Closed loop system for broken grain content developed			X	X	X		
	Closed loop system to maximise hulling efficiency developed					X	X	X
	System implementation					X	X	X
4.3	Quality assurance systems and post harvest pest management							
	IPM strategies evaluated							
	- Ethyl formate	X	X Commenced					
	- CO2 fumigation	X						
	- Cool temperature treatment	X	X Commenced	X				
	- Phosphine fumigation			X	X			
	- Carbonyl sulphide			X	X	X		
	- Designing out pests	X	X Deferred	X				
	HACCP systems							
	- rice based foods plant	X Commenced	X ✓					
	- mills and stock food plants	4 (flour mill)	X Commenced	X				
	- rice receival sheds and on-farm				X	X	X	X
4.4	Rice hull use							
	Potential for energy conversion determined	X ✓No potential	X n/a	X				

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
	Potential for hull based alternatives determined	Commenced	X Continuing	X	X			
	Other uses for hulls investigated				X	X	X	X
4.5	New rice-based foods							
	Quick cook rices developed	X Commenced	X ✓	X	X	X		
	Feasibility for pouch packed cooked and frozen rice	X Commenced	X ✓ Feasibility study completed however RCL has deferred decision on commercial viability					
	Frozen rice products developed and test marketed			X	X	X	X	
	Development of pouch packed products		X Commenced	X	X	X		
	Evaluation of waxy rice flour	X Commenced	X No application	X	X			
	Potential to produce and market rice noodles evaluated	Evaluated and discontinued	Re-evaluated					
	Other rice-based products evaluated				X	X	X	X

X = To be completed (in some cases this exercise is repeated over several years).

✓ = Achieved (if not achieved, status provided)

EDUCATION AND TRAINING

Education and technology transfer are pivotal to the functioning of any industry. The rice industry is no exception. The Education Program of the Rice CRC acts as an information conduit between the CRC and the industry.

Prior to establishment of the Rice CRC, the systems for transfer of production technology to rice farmers were well developed. This was not so true for enhancing the skills base in the processing sector. There was also a paucity of education programs aimed specifically at the needs of the rice industry. This applied equally to skills-based training, undergraduate and postgraduate education. For this reason, education was allocated a specific program of the Rice CRC.

PROGRAM 5

EDUCATION, SKILLS DEVELOPMENT AND TECHNOLOGY TRANSFER

Program Leader:

Mr Peter Cregan\Dr Phil Eberbach
Charles Sturt University
Wagga Wagga

Education is an important focus of the Rice CRC. This Program aims to raise awareness of rice issues at all levels including school, rural and urban communities, undergraduate and postgraduate. Four Sub-Programs address these areas.

5.1 Sustainable rice production through farmer education and community awareness (5101)

Sub-Program Leader:

Mr Warwick Clampett
NSW Agriculture
Griffith

The aim of the Sub-Program is to raise awareness of the Rice CRC objectives and progress within rural and urban communities.

Progress

The rice area of NSW is well serviced by the district agronomist network of NSW Agriculture. This network uses resources of the parent organisation and is supported by RIRDC to publicise research results through seven pre-season meetings, field days and more than 200 discussion group meetings. Much of the extension information is delivered through the Ricecheck objective management program.

The Rice CRC activities have been publicised through this network. Some activities were components of the Rice Field Day at Yanco Agricultural Institute in March 1999. These

included general Rice CRC information and information relating to Sub-Programs 1.1, 1.2, 2.1, 2.2 and 3.2.

Other information was provided to rice pre-season meetings in August and September 1998. Regular contact between the Rice CRC and district agronomists has ensured that progress within the Rice CRC Programs with potential for extension is regularly updated so extension of successful projects will be a seamless operation.

A training module on net recharge management for the Coleambally Land and Water Management Plan Education Program was developed and presented by Mr John Madden on two occasions in August 1998. Three Coleambally Irrigation Corporation staff and 39 members of the irrigation community attended the training module and additional training was provided to Coleambally Irrigation Corporation staff.

5.2 Extension and information technology methods (5201)

Sub-Program Leader:

Mr A (Tony) Dunn
Charles Sturt University
Wagga Wagga

Aims are to:-

- * explore opportunities to develop and apply “new knowledge exchange systems” such as the internet;
- * compare and evaluate new and existing extension and communication methods and technologies; and
- * augment existing extension and farmer information exchange systems with improved technologies.

Progress

The Sub-Program commenced in October 1998 with the appointment of Ms Elaine Murray to a Masters project. Her project will include course work in extension, social research methods and website design. Her initial literature review is nearing completion and a research project is under development.

The project will study use of the internet by farmers and factors that influence such use. The project will be conducted in conjunction with Coleambally Irrigation Corporation as Ms Murray has now been engaged to work with that organisation.

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)

Learning opportunities for new rice farmers have been provided through NSW Agriculture's "Rice for Profit" short courses. These cater for 20 to 40 participants each year and, although aimed at new or prospective growers, have also been popular with existing growers.

There is a need for additional opportunities for new and existing rice growers and also for agribusiness consultants to farmers.

There is also considerable scope for skills development within the processing sector. These opportunities should be fully accredited and provide scope for entry into more advanced training. With the trend toward quality assurance at all levels of the food industry there will be additional training needs for the production and processing sector.

This project aims to create and provide accredited skills training for the production and processing sector.

With the establishment of a steering committee, initial training needs were identified and course outlines developed to address these needs. The steering committee sits three times a year to monitor the needs of the industry and maintain the relevance of course material. Committee members were selected from all areas of the rice industry, including Ricegrowers' Association of Australia, Ricegrowers' Co-operative Limited, NSW Agriculture and Murrumbidgee College of Agriculture.

Course outlines developed so far include an introductory course for rice farmers based on the "Rice for Profit" course, a shorter one-day course for retail agronomists servicing rice farmers, and a three-day rice irrigation course. The introductory rice farming course has been developed to address areas not covered by the Rice for Profit course and has addressed issues such as continuity of information, flexible delivery, presenter availability and increasing number of participants. The retail agronomist course was developed to enhance service industry representatives' skills and knowledge of the unique needs of rice farmers, including areas such as Integrated Pest Management, Integrated Water Management, rice agronomy and rice irrigation. The rice irrigation course focuses on improving water use efficiency through understanding soils, water delivery, scheduling and planning.

Completion and piloting of the irrigation course and agronomist course are due before the commencement of the 1999/2000 season. The introductory rice farming course is scheduled for completion during the 1999/2000 season and to be available for participants at the end of the season. All courses developed will be aligned with current industry competencies leading to course accreditation.

Other areas of education and training identified by the committee include quality assurance (both production and processing), development of grower groups for education and training, benchmarking, rice processing (value added products, by-product development) and public awareness of the Australian rice industry. These areas are currently being prioritised and

evaluated for course development and implementation in the 1999/2000 season. The steering committee will maintain focus on the training needs of the industry throughout the Sub-Program.

Rice CRC Education Officer (5302)

Project Leader:

Mr Geoff Creek
Murrumbidgee College of Agriculture
Yanco

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. Specific objectives are to:-

- * develop specific display material and presentations;
- * arrange visits;
- * co-ordinate or participate in presentations for schools, community groups and international visitors.

An Education Officer will be appointed to this project in 1999, but there has already been significant development of material and course presentation as part of the Rice CRC Programs and NSW Agriculture's activities outside the Rice CRC.

5.4 Professional development for sustainable rice production (5401)

Sub-Program Leader:

Mr Peter Cregan\Dr Phil Eberbach
Charles Sturt University
Wagga Wagga

This Sub-Program currently focuses its activities on developments in the tertiary education arena, with the development of modular style teaching materials aimed at undergraduate and postgraduates.

Specific objectives are to:-

- * provide undergraduate and postgraduate course material and experience necessary for students intending to work in 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 to further develop their qualifications and experience.

While this material has been developed to include tertiary teaching programs its modular design was deliberate, allowing it to be readily adapted for delivery in short courses to growers, extension personnel, processors and to other service providers.

Dr Siva Sivapalan was employed early on in the life of the Rice CRC as an agronomy lecturer at Charles Sturt University. A more recent development has been the employment of Dr Chris Blanchard as a lecturer in rice cereal technology.

** Undergraduate*

Undergraduate course material has been prepared in modular form for delivery to students interested in both the production and processing aspects of the rice industry.

Dr Sivapalan has prepared study material dealing with agronomic aspects of rice-based farming systems. This topic has been prepared as a package containing four independent modules:-

- Module 1. Australian Rice Industry
- Module 2. Rice Water Management
- Module 3. Sustainable Rice Production
- Module 4. Rice Production Systems

This package is on offer to undergraduate students for the first time in 1999 during the spring semester. Approximately 10 students have expressed an interest in undertaking the subject in this semester. In addition, the study material has been produced in stand-alone modules for use in short courses of a set standard to satisfy the requirements of growers, extension workers and other relevant personnel. Dr Sivapalan is now producing study material related to the agronomy of irrigated summer crops, which will complement the material encompassed within rice-based farming systems.

Dr Sivapalan has also presented undergraduate course modules in three courses to a total of 251 students.

Since arriving Dr Blanchard has developed material for a subject of Food Science Technology for inclusion in the Bachelor of Food Science and intended for inclusion in the new course of Food Nutrition and Dietetics. The study material has been produced in three modules:-

- Module 1. Principles of Molecular Biology
- Module 2. Applications of Molecular Biology,
- Module 3. Ethics of Biotechnology.

This material is designed in modules so that each module can be adopted for use in short course delivery mode to service the needs of workers in the rice processing industry.

** Postgraduate*

At present 17 postgraduates have been appointed to studentships across the Sub-Programs and across collaborative institutions within the Rice CRC. The cross-institution supervision of these studentships is proving successful and is producing true collaboration and cooperation. At this stage, Mr Vincent Lanoiselot has successfully completed his period of study with the Rice CRC and has returned to France. Another five postgraduate students are to commence in the very near future, with an additional four studentships expected to be filled in the coming year.

Name	Commence- ment Date	University	Type of postgraduate enrolment (PhD, MengSc, etc.)	Supervisor and Associate Supervisors	Funding source(s) CRC/Uni/ etc	Thesis Title (Related CRC Sub-Program)	Graduate Employment
Mr Robert Duncan	17-8-98	Univ of Sydney	Masters	Dr Graeme Batten (NSWAg) Dr Lindsay Campbell (SU)	CRC	An investigation of factors influencing the deposition of iron and zinc in rice grain. (2.3)	n/a
Mr Andrew Eamens	19-2-99	Charles Sturt Univ	PhD	Dr Chris Blanchard (CSU) CSU/NSW Ag	CRC & CSU	Investigation of the molecular mechanisms of starch quality (3.4)	n/a
Ms Zara Evans	1-3-99	Univ of Sydney	Honours	Dr Lindsay Campbell (SU) Dr Graeme Batten (NSWAg)	SU	Amino acids and minerals in high protein rice (2.3)	n/a
Mr Mohammad Ezaz El Mamun	4-5-98	Univ of Sydney	PhD	Dr Bruce Sutton (SU) (linked to cold program)	CRC	The role of callose in cold damage of rice pollen (2.2)	n/a
Mr Tim Farrell	1-8-98	Univ of Qld	Masters	Assoc Prof Shu Fukai (QU) Mr Rob Williams (NSWAg)	Self - funded	Genotypic variation and expression of low temperature tolerance in rice (2.2)	n/a
Ms Sussan Fernandes	1-7-98	Univ of Sydney	PhD	Dr Liz Dennis (CSIRO) Dr Lindsay Campbell (SU)	CRC	Molecular basis of cold induced male sterility in rice (3.2)	n/a
Mr Thusitha Gunawardena	1-4-99	Univ of Queensland	PhD	Dr Shu Fukai (linked to cold program)	ACIAR & CRC	Effect of low temperature during the reproductive stage in rice (2.2)	n/a
Mr Stefan Hansen	1-1-99	Charles Sturt Univ	Honours	Dr Stuart Helliwell (CSU) Dr Mark Stevens (NSWAg)	CRC	Examination of the rice snail, <i>Isidorella newcombi</i> , as a biomonitor for pesticide contamination of aquatic systems (2.4)	n/a
Ms Rama Heidari	1-6-98	Charles Sturt Univ	PhD	Dr John Oakeshott (CSIRO) Dr Gavin Ash (CSU) Dr Robyn Russell (CSIRO)	CRC	Bioremediation of pesticide residues in drainage waters (1.3)	n/a
Ms Karen Herbert	Feb 1999	Univ of Sydney	PhD	Dr Bruce Sutton (SU) (linked to cold program)	CRC	Pathways of assimilate transport within the rice anther (2.2)	n/a

Name	Commence- ment Date	University	Type of postgraduate enrolment (PhD, MengSc, etc.)	Supervisor and Associate Supervisors	Funding source(s) CRC/Uni/ etc	Thesis Title (Related CRC Sub-Program)	Graduate Employment
Mr Vincent Lanoiselet	1-4-98 (finished)	Charles Sturt Univ	Honours	Dr Ric Cother (NSWAg)	CRC	The production, germinability and infectivity of survival structures of <i>Rhynchosporium alismatis</i> , a candidate mycoherbicide for the control of <i>Alisma lanceolatum</i> and <i>Damasonium minus</i> in rice.	(Returned to France)
Ms Elaine Murray	1-10-98	Charles Sturt Univ	PhD ¹	Mr Tony Dunn (CSU) Mr Ken Eustace (CSU) Coleambally Irrigation	CRC	Enhancing information exchange in farming communities. (5.2)	n/a
Mr Xu Peng	1-8-98	Univ.of NSW	PhD	Dr Yaping Shao (UNSW) NSW DLWC	CRC	A new integrated system for modelling land salinisation – with emphasis on the prediction of salinity in irrigation areas (1.4)	n/a
Mr Wayne Pitt	9-2-98	Charles Sturt Univ	PhD	Dr Gavin Ash (CSU) Dr Ric Cother (NSWAg)	CRC	Addressing factors that affect the host range and virulence of <i>Rhynchosporium alismatis</i> , a potential biological agent of Alismatacae weeds in rice (2.4)	n/a
Ms Alexa Seal	1-12-98	Charles Sturt Univ	PhD	Prof Jim Pratley (CSU) Dr Laurie Lewin (CRC)	CRC	Allelopathy in rice to control weeds in NSW (3.2)	n/a
Mr David Smith	3-4-98	Charles Sturt Univ	Masters	Dr Liz Humphreys (CSIRO) Doug Godwin (CSIRO) Dr Phil Eberbach (CSU)	CRC	Using models to quantify the benefits of crops after rice (1.2)	Withdrew June 1999
Ms Sarah Spackman	2-2-98	Charles Sturt Univ	PhD	Dr David Lamb (CSU) Mr Jon Medway (CSU) CSU/NSW Ag	CRC	<i>Using airborne multispectral imaging to manage within-paddock variability in rice production (2.1)</i>	n/a
Ms Stephanie Vaughan	22-2-99	Charles Sturt Univ	PhD	Dr Melissa Fitzgerald (NSWAg) Dr Chris Blanchard (CSU)	CRC	Investigation of sun cracking in rice (3.4)	n/a

¹ Converted from PhD to Masters 5/99 following Ms Murray taking up position with Coleambally Irrigation Corporation (Land & Water Management Plan). Work and studies will compliment the Rice CRC.

Name	Commence- ment Date	University	Type of postgraduate enrolment (PhD, MengSc, etc.)	Supervisor and Associate Supervisors	Funding source(s) CRC/Uni/ etc	Thesis Title (Related CRC Sub-Program)	Graduate Employment
Ms Andrea Wilson	30-3-98	Charles Sturt Univ	PhD	Dr Mark Stevens (NSWAg) Dr Robyn Watts (CSU)	CRC & CSU	The effect of different management regimes on aquatic consumers and food sources in rice agroecosystems (2.4)	n/a

Further initiatives planned for Program 5 in the coming year include:-

- * funding vocational opportunities for undergraduate students as both Honours scholarships and summer studentships, and the investigation of opportunities for undergraduate streaming;
- * improving opportunities for management training of current senior level postgraduate students;
- * investigating the advantages of value adding to postgraduate studentships by improving the opportunities to work with industry and sponsoring travel to conferences; and
- * establishing an annual Rice CRC and RIRDC postgraduate students forum, where students will be invited to attend and present a synopsis of their current work. This forum will provide a basis by which some of the work undertaken by the students is released to other researchers, extension officers and other Rice CRC and RIRDC members.

Currently the Program has 17 postgraduate students comprising:

- 13 PhDs
- 2 Masters
- 2 Honours

There are currently five postgraduate students expected to commence in the near future, with an additional four PhD studentships still to be appointed.

MILESTONES

	Milestone	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
5.1	Farmer education and community awareness							
	Extension officer awareness	X Partially completed	X ✓	X	X	X	X	X
	Extension program development		X ✓	X	X	X	X	X
5.2	Extension and information technology methods							
	Appointment of research student	X Delayed	✓ Completed		X			
	Baseline extension study	X Commenced	X ✓ Completed					
	Subsequent studies			X	X		X	X
	Evaluation of novel extension technology	X Commenced	X In progress	X	X			
	Appointment of Post Doctorate Fellow				X			
	Comparison with existing techniques			X	X	X	X	X
5.3	Skills development							
	Industry education officer appointed	X ✓						
	Training needs analysis completed	X Commenced	X ✓					
	Training courses developed for:							
	- production		X ✓	X				
	- industry		X ✓	X	X	X		
	- leadership			X	X	X		
	- facilitation		X Commenced	X	X	X		
	Training courses run		X Commenced	X	X	X	X	X
	Information officer appointed		X Commenced					
	Display material arranged		X Commenced	X	X	X	X	X
5.4	Professional development							
	Lecturers appointed:							
	- production	X ✓	X ✓					
	- cereals	X Recruitment underway	X ✓ Completed					
	Students appointed	X 7/16 commenced	X 17/23 commenced	X	X	X	X	X
	Tertiary courses developed and presented		X Commenced	X	X	X	X	X
	Scholarship coordination	X commenced	X Commenced	X	X	X	X	X

X = Year due for completion (in some cases this exercise is repeated over several years).

✓ = Achieved (if not achieved, status provided)

UTILISATION AND APPLICATION OF THE RESEARCH, COMMERCIALISATION, LINKS WITH USERS

The Rice CRC aims to guarantee the sustainability of the Australian rice industry through research, education and transfer of technology. There are various target groups depending on the type of information being generated. The mode of delivery also varies depending on the target.

In 1998/99 there were 2,342 farms producing rice in NSW. The majority of these are small business units, although there was a small increase in the number of corporate farms. Transfer of production technology to the rice farmer has always been a strong feature of the rice research and development program. These linkages will be utilised by the Rice CRC to maintain a strong technology transfer program for the production orientated programs.

Increasing pressure is being placed on these enterprises to meet new standards of water use and environmental management. It is the responsibility of this CRC to provide research information that will assist farmers to meet these challenges. It is important that the research be linked through existing organisations such as the irrigation corporations and community based Land and Water Management Plans. The links are developing, particularly with irrigation corporations and information is being distributed as it is developed.

Stakeholder	Information	Involvement
Rice producers (2,342 farms in NSW)	Production Sustainability (watertables, salinity, drainage water quality, pest control)	Extension Involvement as advisors at project, program and Board levels Cooperation
Processors (eg, Ricegrowers' Co-operative Ltd)	Processing Sustainability (pests) Quality Assurance New producers	Involvement in research
Irrigation corporations - Murrumbidgee Irrigation Limited - Coleambally Irrigation Corporation - Murray Irrigation Limited	Sustainability (watertables, salinity, drainage water quality)	Involvement as advisors Cooperation Rice CRC project participants
Agribusiness Companies (chemical and fertiliser distributors)	Sustainability (pest control) Productivity (eg, fertilisers)	Extension Education Involvement in research
Land and Water Management Plan groups	Sustainability (watertables, salinity, drainage water quality) Productivity	Liaison Land and Water Management Plan project committees Education programs

Examples are:-

- * Rice CRC researchers (eg – participants involved in irrigation corporation and Land and Water Management Plan committees;
- * Irrigation corporation and Land and Water Management Plan members - participants in or on Rice CRC project steering committees; and

- * Rice CRC researchers developing and teaching Land and Water Management Plan education modules (viz; Natural Resource Management).

Other links are with Ricegrowers' Co-operative Limited. This organisation is responsible for milling and marketing all NSW rice. Processing technology developed as part of the Rice CRC is available to RCL and implementation plans are a component of technology development.

The annual Rice Field Day at Yanco Agricultural Institute in March 1999 provided a further opportunity to promote some of the programs of the Rice CRC and to improve contact with the rice farming community. A similar opportunity was provided at the Murrumbidgee Farm Fair.

Other important links were facilitated in a number of project areas. A brief description of these follows:-

Sustainability of natural resources

Discussions occurred with Murray Irrigation Limited, Murrumbidgee Irrigation Limited, Coleambally Irrigation Corporation and Jemalong Irrigation Limited regarding use of sodicity within rice land suitability assessment procedure.

In regard to the on-farm net recharge management project, a presentation on SWAGMAN Farm was made to the Manager and the Environment Manager of Coleambally Irrigation Corporation. Numerous interactions with Coleambally Irrigation Corporation staff occurred, including training three staff in the use of SWAGMAN Farm. The Net Recharge Management training module was run twice in August 1998. This was attended by three Coleambally Irrigation Corporation staff and 39 members of the farming community.

Mr Ary van der Lely presented the findings of the soil salinity assessment and prediction model to representatives of the three major irrigation providers (Murrumbidgee Irrigation Limited, Coleambally Irrigation Corporation and Murray Irrigation Limited) at a seminar at CSIRO Land and Water, Griffith.

The findings of the wheat after rice project were presented and reviewed at the project steering committee meeting in January 1999. This meeting included two farmers and three district agronomists. The findings were reported by NSW Agriculture in the Denimein Land and Water Management Plan Community Newsletter, No.10, February 1999 (Mr Lindsay Evans. "Wheat after rice - \$ and watertable benefits"). A talking poster presentation was made to over 100 farmers who attended a rice field day at Yanco in March 1999. A static poster display was provided for the Rice CRC tent at the Murrumbidgee Farm Fair at Yanco in May 1999.

Sustainable production systems

As part of the site selection process for Project 2102 (use of airborne digital imaging to assess within-paddock variability in rice production), Ms Sarah Spackman completed the following:-

- * presented an overview of the airborne imaging technology at a Yenda region Landcare conference in February 1999;
- * attended and presented at two "farm meetings" in conjunction with Yenda Producers; and
- * visited three farms to consult participants and discuss project strategies.

Genetic improvement for sustainable production

On the basis of the positive outcomes from preliminary research in Project 3102 (new indirect selection techniques for improving rice potential), a full proposal is being developed to begin applying these new techniques within the Rice Breeding Program at NSW Agriculture's Yanco Agricultural Institute.

The results of research in Project 3301 (microspore and spikelet culture in rice) are available to all programs within the Rice CRC and the project staff at the Plant Breeding Institute (PBI) at Cobbitty collaborate closely with the researchers on the main campus of University of Sydney. Visits to the PBI are encouraged and all information and technology is available on request.

Cold-induced pollen sterility is a serious problem, causing severe yield losses for rice growers (down to 30% of normal yields). Little is known about the molecular basis of the problem of cold-induced pollen sterility. This is a major hurdle for breeders to develop efficient breeding strategies. A better knowledge of the molecular basis of the problem will enable us firstly to design strategies to genetically engineer cold tolerance of rice pollen. Secondly, rice breeders will be able to take advantage of the information provided by this project to fine-tune and develop new breeding strategies. Rice plants with improved cold tolerance will be included in breeding programs and will ultimately be commercialised.