COOPERATIVE RESEARCH CENTRE FOR SUSTAINABLE RICE PRODUCTION

ANNUAL REPORT 2000/2001

Part B

RESEARCH

The Rice CRC research program is focused on outcomes that will underpin the sustainability of the Australian rice industry. Its four research programs address the general areas of resource use, production systems, genetic improvement and processing. The research programs interact with the education program to ensure integration of research, education and technology transfer objectives. The CRC research program complements the largely production-focused program funded through RIRDC.

The research reported in this section highlights the range of projects and the level of cooperation that has been encouraged through this CRC.

PROGRAM 1

SUSTAINABILITY OF NATURAL RESOURCES

Program Leader:
Dr Liz Humphreys
CSIRO Land and Water
Griffith

Both the on-farm natural resource base and the wider environment are susceptible to degradation by irrigated agriculture. The regional and national importance of the rice industry, and the long-term ponding of irrigation water for rice culture present unique challenges to management for environmental and economic sustainability. These challenges include rising watertables leading to waterlogging and root zone salinisation, contamination of surface and groundwaters by irrigation drainage, and degradation of river, riparian and floodplain ecosystems due to altered water regimes.

Research in Program 1 is directed towards:-

* reducing net recharge of watertables

* increasing water use efficiency

* improving drainage water quality

while maintaining or increasing profitability.

This will be achieved through the application of new knowledge, technologies and tools developed by Program 1, including:-

* improved technologies and guidelines for rice soil suitability assessment;

* guidelines for the identification and treatment of leaky on-farm channels and drains;

* rice cultural systems and rotations with higher water use efficiency and lower net recharge;

* methods for dealing with contaminated drainage waters;

* point, farm, district and regional scale models to assess the impacts of changes in management on environmental sustainability and economic viability; and

* remote sensing methods to identify crop type and evaluate water use efficiency across regions.

Case Study

Methodology supports farm planning to reduce groundwater accessions

(G Beecher, B Dunn, I Hume, S Akbar)

EM31 surveys have had significant benefits to on-farm water use efficiency and have had direct influence on reducing groundwater accessions through application in irrigation farm management, design and layout. Use of the electromagnetic induction instrument (EM31) has been rapidly adopted within Land and Water Management Plans. This has directly addressed strategic research and extension initiatives to develop practices to improve on-farm water use efficiencies.

Greater accuracy of identification of land suitable for rice production has been achieved through improvements in instrumentation, survey and interpretation technologies associated with Electromagnetic instruments, (particularly the Geonics EM31). This work was initiated and undertaken by NSW Agriculture, with support from the RIRDC and the Rice CRC.

In its Environmental Report 2000, Coleambally Irrigation Limited reported that EM31 field surveying had been completed or commenced on more than 320 farms since 1998. The report stated that the remaining 82,000 ha in the Coleambally, Kerarbury Channel and Outfall District Land and Water Management Plan (LWMP) areas would be surveyed over the next three years.

"EM 31 surveying is a prerequisite for obtaining LWMP incentives and is a high priority component of the Coleambally LWMP Environmental Report 2000," the report said.

At the Rice CRC-supported Electromagnetic Techniques in Agricultural Resource Management Conference (Yanco Agricultural Institute, 3-5 July, 2001), Murray Irrigation Ltd Rice Officer, Chris Shaw reported: "Over 80,000 ha of rice land has been surveyed using EM31 technology in the Murray irrigation area of operations since 1996/1997. A high level of confidence has been developed in the use of the technology. Factors that influence the EM31 values are well understood and are now being taken into account with survey and drilling strategies."

Case Study

New concepts in cropping systems

(J Thompson, E Humphreys and G Beecher)

Research conducted by John Thompson has shown rice can be successfully grown on beds in the southern NSW environment, with a water use saving of 10% to 15% but at a yield cost of about 15% in the absence of deep water at panicle initiation (PI). (It is thought this yield decline was due to moisture stress and reduced nitrogen uptake).

With deep water from PI, yields and water use are comparable to those of traditional aerial sown rice. Therefore, considered alone, there wouldn't be much point to growing rice on beds.

However, significant interest in growing rice on beds has in fact been generated. Growers have begun trialing the technique because it provides the opportunity to adopt permanent bed cropping systems that include rice. The potential then exists to increase profitability and water use efficiency, and reduce recharge. Permanent bed cropping systems offer the following benefits:-

1. increased cropping flexibility – opportunity to grow crops in rotation with rice that can't be grown profitably on the flat and, because the beds are already in place, the possibility of rapid response to market opportunities;

2. higher yields of crops traditionally grown on the flat in rotation with rice due to improved drainage and soil structure;

3. increased double-cropping opportunity through quicker turn-around (maximise use of land resource);

4. better disease, weed and pest control through increased diversity in profitable rotation options;

5. increased water use efficiency through higher yields from crops grown in rotation with rice and increased opportunity for establishing crops immediately after rice;

6. reduced recharge through increased opportunity to establish crops after rice.

The major benefit is the substantial cost reduction from doing away with the change from a contour layout for rice to a bed layout favoured for the other crops.

Several irrigators are considering growing rice on beds in 2001/2002 and a collaborative research project on permanent bed cropping systems is likely to commence under the umbrella of the Rice CRC, with funding support from ACIAR and RIRDC. The Rice CRC has fostered these exciting developments.

Case Study

Groundwater and salinity management tools and guidelines underpin land and water management planning in Coleambally Irrigation Area

(S Khan, Z Wang, E Christen and B Wang)

An influential modelling tool has emerged from rice water use, climate variability and groundwater dynamics studies in the Coleambally Irrigation Area (CIA) using Geographical Information Systems (GIS) and groundwater models. SWAGMAN Farm, a user-friendly, farm level hydrological economic optimisation model, has been developed through the incorporation of crop, soil, groundwater and economic research.

The CIA studies have led to the delineation of five groundwater management zones with distinctly different groundwater dynamics. As a consequence, Coleambally Irrigation Cooperative Limited (CICL) has restructured the implementation of its Land and Water Management Plan to maximise interaction, understanding and information sharing between environmental staff and irrigators within each of these zones.

The company plans to base its future pumping strategies, incentives and policies on the findings of this work and similar studies and educational programs are commencing in the Murrumbidgee and Murray Irrigation Areas.

Results from SWAGMAN Farm modelling have been compared with watertable changes in the Coleambally and Murray regions and have gained the confidence of farmers and irrigation area managers. The SWAGMAN Farm model is an important educational tool, helping individual farmers understand the impacts of different land uses on watertables, root zone salinity and gross margins and identify more sustainable but profitable options. CICL environmental staff have been trained in its use as well as the interpretation of hydrogeological studies to explore land and water management options with farmers.

About 150 farmers have completed an educational module on net recharge management, including hands-on use of the SWAGMAN Farm model to examine the effect of a range of land uses and biophysical factors, such as rice crop water use, on watertables and salinity.

The CIA groundwater model has been refined with the aid of SWAGMAN Farm to include salt transport and appropriate deep and shallow bore pumping strategies have been identified. This will enable maximum shallow watertable and salinity control while providing additional water for irrigation.

- Rice CRC, CSIRO Land and Water, CICL, ACIAR, Murray Irrigation Limited, NPIRD have all contributed to this work

1.1 Measurement and mapping

Sub-Program Leader:
Mr Geoff Beecher
NSW Agriculture
Yanco

The aim of the Sub-Program is to develop tools for better land use mapping and land capability assessment.

Tools are required that provide better measurement, in space and time, of factors critical in natural resource management for rice-based farming systems.

Improved land use capability assessment techniques are needed to enable farm planning to minimise groundwater recharge from rice fields, channels and drains.

Better remote sensing tools are required for monitoring crop areas and types, and for identification of groundwater recharge sites.

Better prediction of groundwater recharge from rice growing (1102)

Project Leader:
Mr Geoff Beecher
NSW Agriculture
Yanco

Objectives

Refining electromagnetic (EM) methodology to include soil chemical characteristics in rice land assessment.

Progress

In collaboration with Murray Irrigation Limited and Coleambally Irrigation Cooperative Ltd, further rice fields were selected from the Murray Valley and Coleambally irrigation areas. These fields covered a range of soil types and had low to moderate EM31v values (ECa 30-150 mS/m). These fields were specially selected because they had been previously assessed as unsuitable for rice growing on the basis of current soil textural criteria. However these sites met the acceptable recharge limits.

Four or five EM31v classes were defined for each rice field based on the frequency distribution of EM31v values in the field. The mapped EM31v values were used to randomly locate five sampling sites in each EM31v class. At each sampling site, soil samples were taken to a depth of 150 cm. Saturated soil paste extracts were prepared and the mean SARe, ESPe and ECe in the (0-60 cm) and (60-150 cm) soil profile intervals were determined for each EM31v class. Chemical analysis of the 1:5 soil to water extracts was also conducted, and sodium concentration was also determined using the Horiba Cardy meter.

Investigations show that, in fields with low to moderate ECa (ECa < 150 mS/m), the sodicity (ESPe) of the 0-60 cm and 60-150 cm depth intervals either increased with increasing ECa or increased to a relatively constant value regardless of soil type or chemistry (Figure 2). For high ECa locations (ECa > 150 mS/m) (Figure 3) the ESPe for both 0-60 cm and 60-150 cm depth intervals was relatively high and constant, irrespective of the ECa value.

When data from all sites investigated are collated (Figure 4) the findings align with the proposed scheme (RIRDC project DAN145A) based on the observation that sodicity in the soil profile plays a key role in controlling recharge from rice growing. However the relationship between EM31v and sodicity is not strong enough to quantitatively predict sodicity (ESPe) in the topsoil (0-60 cm) or subsoil (60-150 cm).

We conclude that EM31v surveys of rice fields can be used to target soil sampling sites within rice fields, allowing an accurate assessment of in-field soil sodicity variation. Maps of soil sodicity variation across rice fields produced from this method may be used to define where groundwater accessions under rice growing can be minimised.

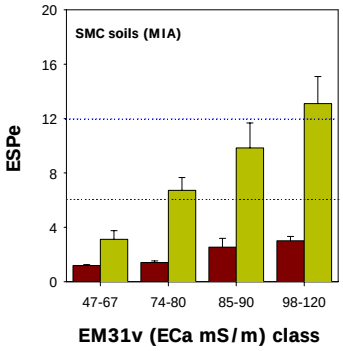


Figure 2: Variation in soil sodicity of samples from different EM classes in the 0-60 cm and 60-150 cm depth intervals of MIA fields where EM31v values were less than 150 mS/m

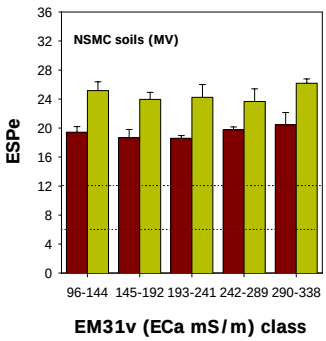


Figure 3: Variation in soil sodicity of samples from different EM classes in the 0-60 cm and 60-150 cm depth intervals of MIA fields where EM31v values were greater than 150 mS/m

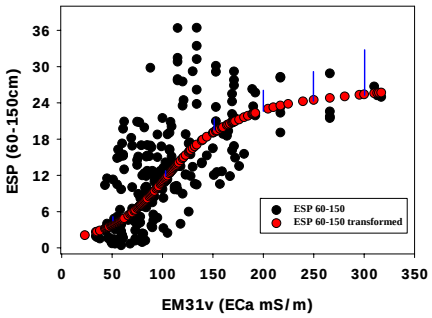


Figure 4: Relationship between EM31v readings and ESP of the 60-150 cm interval of the soil profile over all sites with fitted backtransformed spline relationship. Bars represent standard errors.

Outcomes

Murray Irrigation Ltd is now testing soil samples for sodicity during rice soil suitability testing of 50 rice fields during the 2001/2002 rice season, to further evaluate the possibility of including sodicity in the identification of suitable soils for rice growing in conjunction with ring infiltrometer tests and water meter readings.

Coleambally Irrigation is exploring the use of soil sodicity as a rice soil suitability criteria on a limited number of fields during the 2001/2002 rice season.

Remote sensing of crop types and crop area measurement (1105)

Project Leader:
Dr Tim McVicar
CSIRO Land and Water
Canberra

The project is looking at using spatial technologies (remote sensing, geographical information systems [GIS] and spatial interpolation) to better manage rice-based irrigated agricultural industries in southern NSW.

Objectives

The original objective of the project was to use readily available remote sensing data to map different crop types and to assess their application for regional water use efficiency estimation. It has now been agreed to focus on crop classification rather than assessing changes in regional water use efficiency. Given the hyperspectral data provided by TRW/NASA, project participants have the opportunity to compare LANDSAT TM (a broad band instrument with six reflective bands) to Hyperion (a 220 band hyperspectral instrument) with regard to its ability to classify crops. This is now one of the main objectives of this project's research.

Progress

A comprehensive literature review has been completed and published as a Rice CRC Technical Report. The review paper will soon be submitted to the Australian Journal of Agricultural Research.

A method for assessing horizontal positional accuracy has been developed which reports results for both the Australian and United States mapping standards. This material has been published as a Rice CRC Technical Report and will soon appear in Australian Journal of Experimental Agriculture.

Recommendations on improving horizontal positional accuracy were implemented by Coleambally Irrigation Cooperative Ltd (CICL), including detailed specifications being used in a public tendering process. This has resulting in the digital air photos provided to CICL from the 2000/2001 growing season having a higher quality than those acquired during the

1999/2000 growing season. Specifically, this has resulted in an accurate reference for GIS data creation and registration for the Coleambally Irrigation Area (CIA).

During the 2000/2001 growing season, there has been considerable field work conducted. Thirty-eight soil samples were collected and a 5 m^2 spatial resolution HYMAP (an airborne hyperspectral instrument) was acquired for a focus area of the CIA. Rice plant samples were subsequently collected. *In situ* ground-based hyperspectral measurements were made in support of LANDSAT and Hyperion overpasses.

Outcomes

There are three primary success stories from this project from the past year.

1. The quantification of areal accuracy of photography used for monitoring landholder environmental compliance by CICL. This provides both a method for the CICL to more effectively manage their land as well as a justification for making management decisions from this spatial data.

2. The development and use by CICL of the recommendations from the horizontal positional accuracy report has resulted in CICL obtaining digital air photos from the 2000/2001 growing season which were much better quality than those obtained in previous years.

3. Involvement in the Australian Science Validation Team of the Hyperion sensor has meant that the project has access to Hyperion data for the CIA from NASA. The dataset collected at CIA is the most hyperspectral images acquired of any agricultural growing season anywhere in the world.

Assessing the effect of compaction and clay lining on seepage from on-farm channels and drains (1107)

Project Leader:
Mr Saud Akbar
NSW Agriculture
Yanco

Objectives

The overall objective of this project is to increase the distribution efficiency of on-farm channels and drains through reducing accessions to the groundwater.

More specifically, the project will:-

* assess the effectiveness of impact compaction and clay lining on seepage from on-farm channels/drains;

* assess the longevity of the effects of impact compaction and clay lining on seepage from on-farm channels and drains;

* provide an economic analysis of the farm and regional impacts of channel sealing by impact compaction and clay lining;

* develop a Decision Support System (DSS) to assist irrigators to identify seepage problems and appropriate remedial actions;

* develop two and three dimensional channel and drain groundwater interaction models.

Progress

Commencement of the project was delayed until mid 2001 due to weather conditions that prevented field work (soil sampling, compaction and clay lining).

In the meantime, the field sites have been selected, the equipment needed for the project has been assembled, arrangements have been made for Landpac Pty Ltd to apply the impact compaction treatments, and the sites have been prepared by the cooperating farmers.

1.2 Net recharge management

Sub-Program Leader:
Dr Liz Humphreys
CSIRO Land and Water
Griffith

Net recharge management involves reducing recharge to and increasing discharge from watertables.

Projects are in progress that will:-

* assist evaluation of on-farm options to control watertables and root zone salinity, taking into account economic viability and farmer preferences, individual farms;

* evaluate novel water management and layouts designed to increase irrigation efficiency and/or reduce recharge from rice and rice cropping systems;

* quantify the impact of growing wheat immediately after rice harvest on net recharge and water use efficiency, and knowledge of farmer perceptions of such practices.

Optimising agronomic options at the farm scale (1201)

Project Leader:
Dr Shahbaz Khan
CSIRO Land and Water
Griffith

Objectives

* Further develop a computer model (SWAGMAN Farm) that can be used to assess the environmental impacts of on-farm options to increase water use efficiency, and capable of providing benchmarks for water auditing at a crop, farm and district level.

* Evaluate agronomic options for net recharge management (different crop mixes).

* Develop an enhanced understanding of recharge and discharge components under different climatic and management scenarios.

* Develop an increased awareness and knowledge of the link between resource sustainability and water use efficiency.

Progress

* Crop, soil, irrigation, climatic and economic data sets have been collected for 14 farms in the Murray irrigation districts.

* Rigorous validation of SWAGMAN Farm model processes has been undertaken by applying the model to 14 farms with a range of enterprise, soil and groundwater conditions.

* Simulation and optimisation modes for SWAGMAN Farm have been developed. The simulation mode can be used to assess watertable, salinity and economic impacts of existing or nominated land use, irrigation water use and site and seasonal weather conditions. When run in the optimisation mode, the model can be used to determine the most profitable mix of land uses to avoid watertable rise and root zone salinisation.

* The model processes have been improved by incorporating soil water content accounting processes in the model to provide flexibility in the starting soil profile water content and water availability to crops. An improved method for estimating recharge and watertable rise during the cropping and fallow periods has also been incorporated.

* A range of other improvements in the water and salt balance processes to suit conditions in the Murray districts have been made. Some of these improvements include improved methods for estimating upward movement (capillary upflow) of water and salt from the watertable, and improved definitions of very dry, dry, medium, wet and very wet rainfall and evapotranspiration years for the Murray Valley.

Outcomes

* A Windows-based GAMS-independent version of SWAGMAN Farm has been developed. GAMS (General Algebraic Modelling System) is an expensive software platform with inflexible licence requirements which was used for the previous version of SWAGMAN Farm. The new version is written in C++ language, uses Microsoft Access databases and could be more freely distributed (eg. to farmers).

* A Windows version will be released in 2001 and made available on the Internet.

* Coleambally Irrigation Cooperative Ltd is currently running the model with approximately 50 landholders.

Improving the water use efficiency of rice (1204)

Project Leader:
Mr John Thompson
NSW Agriculture
Deniliquin

Objectives

The project aims to investigate opportunities to improve the water use efficiency of the rice crop by comparing the raised bed layout with conventional aerial sowing. The effect of short season varieties is also being investigated.

Progress

In 2000/2001, a replicated field experiment on a cracking grey clay, compared a conventional aerial sown fully ponded treatment with a rice sown on a raised bed layout. Following establishment, the water level on the beds was lowered and the water maintained in the furrows for the remainder of the growing season. A third treatment, where the crop was combine sown, was abandoned as crop establishment was very poor.

Grain yield from the raised bed layout where the water was maintained in the furrows all season was reduced by 18% (11% for the same treatment in 1999/2000). Although nitrogen fertiliser was applied before sowing, the crop appeared to suffer stress from low nitrogen prior to topdressing at panicle initiation.

A commercial crop in the Jerilderie district of NSW, sown on raised beds, was monitored throughout the season. Establishment and crop growth were satisfactory and the yield from a section of the crop where water was maintained in the furrows throughout the season was equivalent to where the water level was ponded over the beds at panicle initiation.

Outcomes

This project has demonstrated that unless water is ponded from panicle initiation a reduction in grain yield of 10 – 15% is likely, principally through a reduction in harvest index. Restricting water to the furrows of a raised bed layout will reduce crop water use but there is no gain in water use efficiency.

Quantifying and maximising the benefits of crops after rice (1205)

Project Leader:
Dr Liz Humphreys
CSIRO Land and Water
Griffith

Objectives

* To quantify the impacts of growing wheat directly after rice on: crop water use, net recharge of the watertable, root zone salinity, and productivity and water use efficiency of the rice-wheat cropping system.

* To use crop models to predict yields and the impact of wheat after rice on recharge and root zone salinity for a range of seasonal conditions, watertable depths and salinities, soil types and management.

* To develop guidelines for growing wheat after rice.

Progress

Four replicated field experiments have been completed on a Beelbangera clay loam (1998, 1999) and on a Willbriggie clay loam (1999, 2000) to compare the effects on components of the water balance of: (i) stubble retained fallow, and (ii) wheat direct drilled after burning the rice stubble.

Non-irrigated wheat sown after rice harvest dried the soil profile to depths up to 0.7 – 1.0 m, despite around 300 mm of rain, whereas the soil profile in the fallow areas remained near saturation. Yields of around 5 t/ha were obtained for late April sowings, but delaying sowing to the end of June reduced the yield to 3.3 t/ha.

The wheat appeared to lower the watertable during the first half of the season, in contrast with the fallow areas. However, once the neighbouring fields were flooded for rice sowing, the effect of the wheat on the watertable in our small plots was “swamped” by the effects of the neighbouring fields, complicating the interpretation of results. Preliminary calculations suggest considerable benefit in terms of increasing water use efficiency due to making use of winter rainfall and crop water use from upflow from the watertable, and in terms of reduced net recharge.

Calibration and validation of the CERES Wheat and SWAGMAN Destiny crop models is complete. Hundreds of simulations have been completed examining the effect of sowing date, irrigation management, and initial watertable depth, salinity and soil water content on yield, net recharge and soil salinity for up to 39 years of climatic data. The model simulations confirm the importance of sowing wheat early after rice harvest for best yields if not irrigating.

Using 39 years of CSIRO Griffith weather data (1962-2000), non-irrigated early sown wheat yields varied from next to nothing up to 6.5 t/ha, and exceeded 3.5 t/ha in about 50% of years, where the watertable was initially shallow (0.5 m) and fresh (1 dS/m).

Where the initial watertable was shallow and saline (20 dS/m), yields were reduced by 1-2 t/ha compared with a fresh watertable. Frequent irrigation to avoid water deficit produced yields in excess of 5 t/ha, regardless of initial watertable conditions and sowing date. Watertables were generally lowered when the wheat was not irrigated, whereas frequent irrigation usually raised the watertables.

1.3 Surface drainage management

Sub-Program Leader:
Dr Kaye Spark
CSIRO Land and Water
Griffith

Surface drainage management involves quantity and quality aspects. Salt, suspended sediments (turbidity), nutrients and agrochemicals are major pollutants in surface drainage waters. These pollutants can be arrested by reuse of drainage water for irrigation, or by managing them in holding ponds, evaporation basins, wetlands etc. Research is required to determine appropriate management options and design criteria for the range of drainage conditions that exist on rice farms.

The persistence of rice pesticides in floodwaters and how this is influenced by water management and layout (1301)

Project Leader:
Dr Kaye Spark
CSIRO Land and Water
Griffith

Objectives

* To determine the persistence of a range of old and new chemicals in floodwaters on rice fields.

* To determine the effect of water management and layout in rice cropping on the concentration of soluble pesticides and salts in floodwaters.

* To develop a model to simulate, and hence predict, the load of pesticides in irrigation waters prior to drainage in rice growing regions of southern NSW.

Progress

A preliminary experiment was undertaken in the 2000/2001 season to determine the significance of sampling location within bays and across the field. Surface and soil samples were collected from numerous locations on four occasions during the season, and sample preparation and analysis is underway. Dr Wendy Quayle was appointed in mid-April 2001.

The determination of the role of sediments in the persistence of pesticides in rice floodwaters and drains (1302)

Project Leader :
Dr Kaye Spark
CSIRO Land and Water
Griffith

Objectives

* To determine the significance of the soil and soil solution characteristics on the quantity and nature of the suspended matter and surface sediment in rice fields.

* To determine the sorption/desorption characteristics of pesticides sorbed to the soil fractions.

* To determine whether the chemical or physical conditions in flood waters or drainage channels significantly impact on the desorption, and hence resolubilisation of the pesticides.

Progress

PhD student, Mr Greg Doran, commenced in February 2001 and is well on the way with his literature review and development of his research proposal.

Bioremediation of pesticide residues in irrigation drainage waters (1303)

Project Leader:
Dr John Oakeshott
CSIRO Entomology
Canberra

The study forms part of a larger project to develop an enzymatic bioremediation technology for cleaning up pesticide residues in irrigation tail waters and on horticultural commodities.

Progress

This PhD project by Ms Rama Heidari is part of a larger project with several stakeholders whose outputs are licensed to Orica Australia Pty Ltd. Priority pesticides in the overall project include the organophosphate (OP), pyrethroid, carbamate and endosulfan insecticides and the thiocarbamate herbicides. Ms Heidari has worked on the kinetic characterisation of 26 candidate enzymes with potential for OP and pyrethroid degradation. A small number of enzymes had some OP hydrolysing activity but none were as good as another enzyme found elsewhere in the project. Several of the enzymes had good activity against a range of pyrethroids.

Orica Ltd has recently succeeded in its first field trial of the technology, with the most promising OP-degrading enzyme achieving over 90% reduction in OP residue levels in over 80,000 litres of contaminated irrigation drainage water. The technology is not yet ready for implementation on a commercial scale.

Enzymatic bioremediation of pesticide residues in irrigation drainage waters (1304)

Project Leader:
Dr John Oakeshott
CSIRO Entomology
Canberra

Objectives

This study forms part of a larger project to develop an enzymatic bioremediation technology for cleaning up pesticide residues in irrigation tail waters and on horticultural commodities.

Progress

Priority pesticides in the overall project include the organophosphate (OP), pyrethroid, carbamate and endosulfan insecticides and the thiocarbamate herbicides. A PhD student, Ms Kahli Weir, was recently appointed to the project. Her goals at this stage are to develop enzymes to degrade the thiocarbamate herbicide thiobencarb, and a troublesome metabolite of endosulfan, endosulfan sulfate.

1.4 Groundwater management at the regional scale

Sub-Program Leader:
Dr Shahbaz Khan
CSIRO Land and Water
Griffith

The aim of this Sub-Program is to develop tools and guidelines, which can be used to manage shallow watertables and soil salinity. The tools developed under these projects will be able to represent the complex interactions between climate, irrigation, crops, soils and groundwater dynamics and salt transport at paddock, farm, irrigation area and regional scales. The specific goals are:-

* estimation of salt transport and salinisation from farm to regional scale;

* development of options and strategies for managing groundwater systems in rice-based areas; and

* development of management tools to assist water policy reform in rice-based irrigation areas.

Estimation of salt transport and salinisation in rice-based irrigation areas (1401)

Project Leader:
Mr Charles Demetriou
NSW Department of Land and Water Conservation
Parramatta

The aim of the project is to develop guidelines, which will promote the use and management of acceptable quality groundwater in both farm and large scales.

Objectives

The outcomes of the project will be:-

* ability to model flow and salinity processes to estimate salt transport and salt balance at regional and sub-regional scales in rice growing areas;

* an improved understanding of regional salt transport into rivers and streams including seasonal salt discharge;

* ability to design small-scale salinity interception schemes in rice-growing areas;

* adoption of solutions and options which will reduce the adverse impacts of shallow watertables resulting in preservation of the natural resource base and improved land productivity.

The project has been split up into the following two sub-projects.

Modelling of salt transport and accumulation in irrigated areas (1401a)

Project Leader:
Dr Yaping Shao
University of New South Wales
Sydney

Objectives

The aim of the project is to develop an integrated system for modelling salt transport and salt balance on regional scales. The system will be tested and partially verified using data for the Wakool Catchment.

Progress

This project started in August 1998. The PhD student (Mr Peng Xu) is the main person working on the project, under the supervision of Dr Yaping Shao. The coupling of existing models has been completed, including the atmospheric model, the land-surface model and the groundwater flow model, in the earlier stages of the project. The integrated system allows the simulation of soil moisture and water flows in the unsaturated zone, as well as water flows and the watertable of the saturated zone. The modelling of soil hydrological processes is necessary for estimating salt transport and salt balance on regional scales.

A new solute transport module for the unsaturated zone has also been developed. This module has been tested within the framework of the integrated system. Both solute transport models for saturated and unsaturated zones have been linked to enable the modelling of salt transport in the groundwater system.

In 2000/2001, a new dynamic-statistic surface runoff scheme was developed, which is fundamental to the simulation of salt transport by the river system and the estimation of salt balance for the entire catchment. The new scheme is now complete and has been tested. More recently, the surface flow model, DAFLOW, developed by United States Geological Survey (USGS) for modelling water flow in the river system has been added into this system. Coupling of DAFLOW with both MODFLOW and the overland flow module have been completed. This allows the estimation of salt mass discharge from the catchment to be possible. The coupled system has been applied to the Wakool irrigation catchment for the simulation of overland flow, soil moisture, salt solute transport and groundwater flow. The preliminary results show that the functioning of the system is good.

The integrated system that has been developed is probably the most comprehensive and advanced one in Australia.

The developmental work has now been completed and the PhD student is in the process of writing up his thesis.

Modelling and optimisation of groundwater dynamics adjacent to a rice paddock (1401b)

Project Leader:
Dr Noel Merrick
National Centre for Groundwater Management
University of Technology, Sydney

Objectives

The aims of this project are to:-

* examine the dynamics of groundwater and salinity adjacent to a rice paddock during a growing season;

* characterise the heterogeneity of the field site with 3D resistivity imaging, in terms of spatial variability in hydraulic properties and salt distribution;

* develop a MODFLOW/MT3D model of groundwater flow and solute transport at paddock scale and at short time scale; and

* develop a management model at the farm scale, to address options for reduction of salt discharge to water bodies.

Progress

* The final resistivity imaging survey is to be completed in late June 2001.

* Additional work on 3-D visualisation of the resistivity imaging data is being done by a visiting French student as an in-kind contribution; this will be in the form of a number of computer movies.

* Downloading of dataloggers is continuing.

* Competitive applications are being sought from UTS students for the third stage MSc scholarship.

Outcomes

Completion of major milestone activities for this project:- presentation and analysis of resistivity sectional images; presentation and analysis of dynamic groundwater elevations and salinities; development and successful calibration of 2-D and 3-D groundwater flow models; development of 3-D groundwater solute transport model.

During model calibration, the dominant stresses on the aquifer system were found to be rice ponding, rainfall, drainage and evapotranspiration; deep leakage and lateral flow were found to be minor contributors. The salinity concentration beneath a rice bay is lower than beneath an adjacent fallow paddock. Resistivity imaging, direct measurement and solute modelling all confirm that salinity decreases with depth; this suggests active evapotranspiration and salt build-up in the unsaturated zone.

Quantifying climatic and management impacts on shallow watertables and soil salinity (1403)

Project Leader:
Dr Shahbaz Khan
CSIRO Land and Water
Griffith

Objectives

* Develop modelling tools and use them to evaluate regional and farm scale irrigation management practices for their impacts on watertables and root zone salinity.

* Develop database tools for analysis of biophysical data.

* Differentiate between the climatic and management impacts on groundwater levels.

* Develop guidelines for evaluating the effectiveness of Land and Water Management Plans (LWMP's) in irrigation areas.

Progress

This project has made significant progress as outlined below:-

* collection and collation of data for the development of an MIA groundwater model has been completed;

* the MIA model data input has been completed and a technical report has been prepared;

* the irrigation and drainage network has been incorporated in the MIA model;

* solute transport capability has been added to the CIA groundwater model. A number of shallow and deep groundwater pumping scenarios have been simulated through a new associated ACIAR project;

* detailed monitoring of the piezometric network in the CIA is continuing. The monitoring results are helping quantify recharge and deep leakage differences between various parts of the CIA;

* guidelines for deep and shallow groundwater pumping in the CIA have been developed;

* derivation of Standard Precipitation Index (SPI), Decile and Quartile values for comparing historic rainfall trends at the Griffith, Coleambally and Finley stations has been completed. These results show that the past ten years have been relatively dry or normal rainfall years, which has helped reduce shallow watertable conditions;

* investigation of correlation between winter rainfall and watertable changes has been completed and a technical report has been prepared. Results show a strong correlation between winter and annual August SPI (Griffith rainfall) and shallow groundwater pressures;

* data collection has been started to develop three sub-regional models in the Murray Valley and to understand the impact of flooding on shallow watertables.

Outcomes

Groundwater management zones for the CIA have been identified and adopted by Coleambally Irrigation Cooperative Ltd.

Risk-based spatial modelling to identify regional soil salinity trends in irrigation areas (1403b)

Project Leader:
Dr Shahbaz Khan
CSIRO Land and Water
Griffith

Objectives

* Documentation of existing spatial salinity estimation techniques used in irrigation areas of MDBC.

* A regional heuristic GIS protocol to determine salinity trends. This will provide a tool for determination of salinity hazard in rice-based cropping systems on a spatial basis.

* A stochastic model of water and salt balances in irrigation areas, which can consider uncertainties in spatial data, will be developed and applied in a typical irrigation area.

* Salinity hazard maps for a typical rice based irrigation area which can assist in deciding the economic and effective management options.

Progress

* Ms Louisa Best started her PhD research in January 2001. To date a literature review on a range of deterministic, stochastic and surrogate salinity assessment methods has been completed. This review has been complied in the form of a report, which will be presented to Charles Sturt University with Ms Best's research proposal.

* The possibility of establishing detailed salinity monitoring sites in the Coleambally Irrigation Area is being explored in addition to some lysimeter experiments to quantify crop, soil, water, salt and groundwater dynamics.

MILESTONES

	Milestone	Year 1	Year 2	Year 3	Year 4 - 2000/2001	Yr 5	Yr 6	Yr 7
1.1	**Measurement and mapping**							
	Measurement of soil suitability		X RIRDC project					
	Better prediction of groundwater recharge - review indices of recharge - experiments - data collection - reporting	X 4	X 4 X 4 X 4	X 4 X 4 X 4	X 4			
	Water management practices on irrigation farms - evaluating water management practices	X Deferred	X Not CRC - external funding (from LWRRDC) being sought by CSIRO Land & Water)	X 4 Funds acquired from LWRRDC starting January 2000 to enhance existing monitoring project being undertaken by Murray Irrigation with CSIRO Land & Water.				
	Losses from farm channels	X Commenced	X Commenced	X 4				
	Remote sensing of crop types - appoint student - review current methods - collect existing data - develop and test methods - complete project	X Not achieved	Not achieved X Not commenced X Not commenced	Unable to locate suitable student. Project scientist appointed. Commenced January 2000. 4 X Not commenced	X 4 X Deferred due to late project start	X		
	Classification of irrigated soils by remote sensing - review - acquire and compile existing data - conduct research to fill gaps - develop derivative classification maps - integrate technology with existing data systems	X 4 X Deferred	X 4 X Deferred X Not commenced	) This project X) will not proceed X)				
1.2	**Net recharge management**							
	On-farm agronomic options - model testing and refining - economic model developed - options assessed	X Commenced X Commenced X Commenced	X 4 X 4 X 4	X 4 X 4	X 4 X 4			
	Improved soil salinity assessment and prediction model - model testing and refinement Hydraulic loading policy assessment - hydraulic loading review - available models reviewed	X 4	X 4 X) Not commenced. To X) be transferred to Sub-Prog 1.4	 X) Transferred to Project 1403))				

	Milestone	Year 1	Year 2	Year 3	Year 4 - 2000/2001	Yr 5	Yr 6	Yr 7
	- development and application of new models			X)				
	Improved water use efficiency - field trials complete	X 4	X 4	X 4	X 4			
	Crops following rice - survey - field monitoring/trials - review/modelling - alternative crops	X 4 X 4	X 4 X 4 X 4	X 4 X 4	X Not commenced - project deferred X Not commenced - project deferred	X	X	X
	Compaction options - project evaluation - alternative techniques assessed	X 4	X No further work proposed					
1.3	**Surface drainage management**							
	Appointment of staff	X Deferred	Partly achieved	Partly achieved				
	Downstream impacts on the environment - biodiversity survey completed - development of techniques to minimise pollutants	X Commenced in Sub-Program 2.4	X Deferred	X Not achieved	X Not achieved, project only commenced in late 2000	X	X	X
	On-farm management options - desktop study completed - field trials to assess technology - FILTER technology assessed - DSS system developed	X Deferred X Commenced	X Deferred X Deferred X 4	X Partly achieved X Not achieved X Not achieved	X Not achieved, project only commenced in late 2000 X Not achieved, project only commenced in late 2000	X	X	X
	Regional management options - redundancy of measures defined - region-wide options defined	X Partially commenced	X Partially commenced	Not achieved X Not achieved	X Not achieved and no plans to do this	X	X	X
	Smarter farming systems - residual toxicity definition - rapid tests developed - farming system proposals developed and extended	X Partially commenced	X Continuing	Not achieved X Partly achieved in non-CRC project at CSIRO Land & Water, Griffith X Not achieved	X No further work planned on this X Not achieved and no plan to do this	X X	X X	X X
1.4	**Groundwater management at the regional scale**							
	Estimation of salt transport and salinisation - recharge estimation and mapping - transport models - nutrient export and management	X Commenced X Commenced	X Continuing X Continuing X Continuing	X Continuing X Continuing X Not applicable	X 4 X Not achieved and no plan to do this			
	Managing groundwater systems - shallow groundwater pumping options - deep groundwater pumping options	X Commenced X Commenced	X Continuing X Continuing	X Continuing X Continuing	X 4 X 4	X	X	
	Management model to assist reform - allocation strategies optimised		X Continuing	X Not applicable				

	Milestone	Year 1	Year 2	Year 3	Year 4 - 2000/2001	Yr 5	Yr 6	Yr 7
	- integrated surface & groundwater models developed - salt and nutrient strategies included in models	X Commenced	X Continuing X Continuing	X Continuing X Continuing - salt only at this stage	X 4 X Deferred due to late project start	X X	X X	X X

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

4= Achieved (if not achieved, status provided.)

PROGRAM 2

SUSTAINABLE PRODUCTION SYSTEMS

Program Leader:
Prof Graeme Batten
Charles Sturt University
Wagga Wagga

Rice CRC Program 2 addresses strategic issues relating to the long-term sustainability of rice production. The objective is to develop a comprehensive understanding of the mechanisms operating in the soil, plant and biological environment that could be manipulated to achieve high grain yield and high quality while minimising the impact of intensive rice production on the environment. Program 2 seeks a sound understanding of the current requirements for rice production and techniques to reduce the impact of rice on the resource base to ensure sustainable rice cropping for the long term. Significant reductions in water requirements per tonne of rice are sought through improved tolerance to cold, better recovery of applied fertilisers and reductions in chemical usage.

During the fourth year of this Program, 19 projects were in progress. Activities included collecting soils, analysing soils by chemical and physical techniques, growing and collecting rice plants to study reactions to cold, studying the influence of nutrient supply on yield and grain quality, and seeking non-chemical crop protection.

Scientists in Program 2 continue to develop valuable linkages with staff and students in many Rice CRC projects, with RIRDC projects, and with scientists at other Australian and international research centres.

Specific goals are:-

* an improved understanding of the changes in soils used to grow rice to achieve higher yields per unit of water and fertiliser input;

* an enhanced understanding of the ability of the rice plant to respond to changes in its environment, specifically rice which can withstand minimum temperatures 4ºC lower than current varieties at the reproductive stage;

* the development of tools that can be used to monitor soils, the rice plant and its environment. At present the focus is on a reliable nitrogen test for rice soils;

* a technique to grow grains with predetermined mineral or quality traits; and

* decreased dependence on agricultural chemicals for weed and insect control and to maintain comparative freedom from major pests and diseases.

Case Studies

Balancing soil nutrients for sustainability

(G Batten)

To maintain rice yields and quality one must ask the question "what does rice cropping do to soils' nutrients?".

Information has been drawn from many sources to answer this question. The amounts of nutrients added to grow a rice crop were estimated from fertiliser use information supplied by growers who use the NIR Tissue Testing Service of Ricegrowers' Co-operative Limited (RCL). The contributions of nutrients in irrigation water were provided by Murrumbidgee Irrigation Limited. Grain yields were supplied by RCL and estimates of losses when stubbles are burnt were based on published information.

Nutrient balance sheets were calculated assuming an average yield of 9.3 t/ha and 13.3 ML/ha water was used to grow the crop.

The conclusions of this study were that rice crops remove more N, P, K and Zn than growers apply and the removal is greatly enhanced by burning of stubbles. The rice industry now has a base on which to plan for more sustainable farming systems.

Exotic plant disease risk assessed

(G Ash)

The Australian rice industry has enjoyed a lifetime of freedom from serious diseases mainly because of its isolation from the other rice-growing countries. The introduction of new diseases is quite possible because bacterial, fungal, viral diseases and nematodes can be transmitted on or inside rice grains.

Australian climatic conditions and/or rice growing practices are generally unfavourable for most exotic rice diseases. However, two diseases of rice (rice blast and kernel smut) and one plant parasitic nematode genus (root nematodes) have been identified as having the potential to become established in the Australian rice-growing area if ever introduced in South-Eastern Australia.

Rice blast has never been observed on rice in New South Wales (NSW) but its causal agent, *Magnaporthe grisea*, has already been reported on weeds in several costal regions of NSW. Preliminary results indicate that the Australian isolates of *M. grisea* are unable to infect rice. However, simulation modelling using meteorological data for the period 1988-1999 at four locations in the Australian rice-growing region indicated a potential threat existed in two to nine of the 11 seasons.

2.1 Managing soil chemical, physical and biological properties to achieve yield and environmental quality

Sub-Program Leader:
Assoc Prof Scott Black
Charles Sturt University
Wagga Wagga

The state of the soil resource and our ability to manage it are pivotal to rice production.

Nitrogen is a key nutrient in rice production so techniques are required to estimate pre-sowing fertiliser demand and to ensure crop utilisation of the fertiliser. In this Sub-Program the significance of long-term trends in fertility and variability within and between crops is being studied using a combination of traditional chemical and air-borne sensing techniques. These data will provide a base to define potential limits to future production.

A strategic soil nitrogen test for flooded rice (2101)

Project Leader:
Assoc Prof Scott Black
Charles Sturt University
Wagga Wagga

Objectives

The objective of this project is to promote the more efficient use of nitrogen (N) for rice production. This can be done by; (1) encouraging growers to apply all of their crops N fertiliser requirement just prior to permanent flood, and (2) reducing the loss of fertiliser N from the system.

The specific goal of this project is to provide rice growers with a commercial soil N test that is rapid, cost effective and provides quantitative decision support for pre-flood fertiliser N application.

Progress

Research over the last three years has shown an association between N uptake by rice plants and the near infra-red (NIR) spectrum of the soil. However, the predictive ability of the test is not yet good enough to be used commercially. An additional year's research could improve the association to the standard needed for a commercial application. Three promising lines of research are to be pursued: developing a new NIR technique based on local calibrations - for which a large number of soil-incubation samples are needed, using the within-field variability from yield-mapped fields, and further testing of the collected data with an improved multi-variate analysis software package.

Use of airborne digital imaging to assess within-paddock variability in rice production (2102)

Project Leader:
Dr David Lamb
Charles Sturt University
Wagga Wagga

Objectives

This project will:-

* evaluate the ability of airborne digital imaging to detect and map variability in the rice canopy and thereby direct in-field sampling to determine causal factors;

* examine the link between crop yield and airborne-derived maps of variability in emergence and canopy vigour; and

* investigate the role of airborne digital imaging as a means of improving the accuracy of computer model predictions by extending models to incorporate within-field variability.

Progress

Detailed error analyses of using airborne multispectral imaging of rice crops to forecast yield have been completed. Analysis of imagery acquired at mid-tillering and panicle initiation were completed. Imagery was first converted to in-field biomass estimates. These estimates were subsequently used to directly estimate yield (relative estimate) or were fed into the crop growth model "maNage Rice" to predict yield (modelled estimate). The former, while computationally very simple, generates a relationship that will be relevant only for the particular season in question. The relationship must be re-calculated every year and requires intensive sampling of yield to generate the calibration data. The latter, by taking into account climate and local environmental effects, can be applied to imagery acquired in any season and does not require final yield measurements.

Outcomes

Relative estimates of final yield were within approximately 10% of actual. Modelled estimates were able to predict absolute yield (including within-field variability) to within 30% of actual. Further analysis of imagery is in progress.

Quantifying the long-term effects of rice farming on soil properties (2103)

Project Leader:
Dr Harnam Gill
NSW Agriculture
Yanco

Objectives

The aims of the project are to:-

* evaluate the long-term impact of the common rice farming systems on the changes in important properties of the prevalent soils; and

* establish sites typical of the Australian rice farming systems for future monitoring and quantitative assessment of changes in the soil properties pertinent to sustainable rice productivity.

Progress

In 2000/2001, soil samples (378) and were collected from 189 rice paddocks including 24 research trial plots and some fence-lines in 1999/2000 were processed for analysis and analysed for texture, total soil C, N, S, P, available P (Olsen, Colwell and Bray-1), pH, EC, Exchangeable cations (Na^{+}, K^{+}, Ca^{++}, Mg^{++}), and DTPA-extractable Fe, Mn, Zn and Cu.

* *Soil Acidity*

Acidity is relatively pronounced in rice growing soils. In the CIA 50% of the sampled rice paddocks had pH (0.01 M $CaCl_2$) less than 5.0 (0-10 cm), while in the M.I.A. 40% of the paddocks had a pH less than 5.0. Surface (0-10 cm) soils were significantly more acidic than the sub-soil (10-30 cm).

* *Soil Carbon, N, S, and P*

Total soil N had a close relation to the total soil C content of the rice soils. Total soil S and P contents were very similar in amount and their relationship to the total soil C was very similar. The C:N ratio variation was comparatively wider (8-14:1) for the surface (0-10 cm) than the sub-soil (10-30 cm) layer (3.5-11:1).

Total soil organic carbon content in the surface soil of rice paddocks of the CIA was comparatively lower than in the MIA districts. Temporal changes in the organic carbon levels of the surface soil due to rice cropping indicate decreasing organic matter levels of paddocks regardless of the soil types and farming systems (Figure 5). This shows decline in nutrient supplying power of soils particularly N, P, S, and some micronutrients.

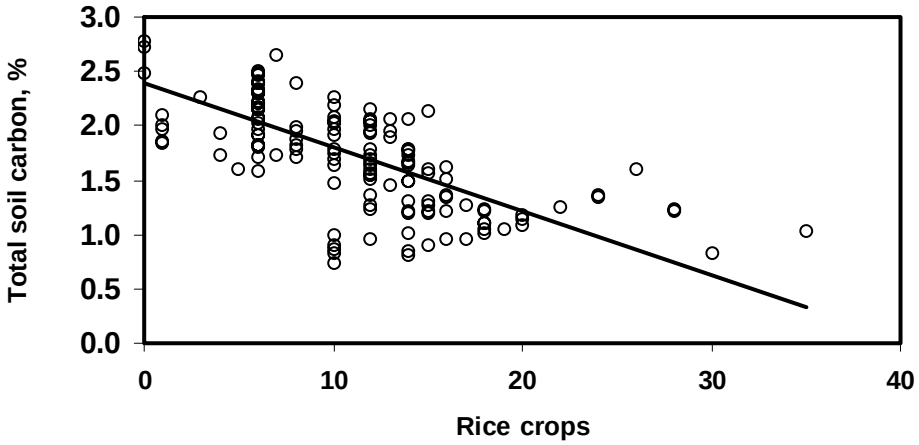


Figure 5: Effect of rice cropping on temporal changes in the total soil carbon content in the surface (0-10 cm) soil of MIA and CIA rice paddocks.

Future work

Data from this project will be linked to nutrient budgets generated in Project 2302 to determine the ability of soils to sustain rice production.

Rotation trials (2105)

Project Leader:
Mr John Thompson
NSW Agriculture
Deniliquin

Objectives

The aim of the project is to maintain the rotation site at the Deniliquin Field Station of NSW Agriculture. The site was established to study the effects of saline groundwater use on common rotation crops in the rice growing system. Saline water is applied to the crops in the rotation phase and effect on yield of all crops in the rotation, including rice, is recorded.

Progress

As the blocks finished their rotation the opportunity to grow continuous rice was taken so that at the end of 1999/2000 the four blocks had grown four, three, two or one consecutive crops of rice. In July 2000 all plots were sampled to 90 cm depth and the soil analysed for salinity and sodicity.

Outcomes

Three or four consecutive crops of rice lowered EC_e to less than 0.7 dS/m for all of the 90 cm of sampled soil profile. A single crop leached salts from the top 30 cm but below this depth, those plots that had been irrigated with saline groundwater, had higher EC_e values. Similarly, three or four consecutive crops of rice reduced sodicity levels to values similar to the control plots that had been irrigated with low salinity channel water. Where only one or two consecutive crops had been grown sodicity levels in the surface 45 cm were still approximately twice those measured in the control plots.

The estimation of soil sodicity and pH using NIR spectroscopy (2106)

Project Leader:
Mr Geoff Beecher
NSW Agriculture
Yanco

Objectives

The development of a quick and inexpensive method for predicting soil sodicity and pH using NIR (Near infra-red reflectance).

Progress

Over 500 soil samples from the 0 to 10 cm depth interval and over 300 soil samples from the 40-50 cm depth interval covering southern NSW rice growing areas have been used in this project. Complete laboratory analyses including pH, EC, Al, Ca, Mg, Na, K and ESP are available for these soils. The soils were all sub-sampled from a soil archive held at Yanco Agricultural Institute. The soils were ground through a centrifical grinder with a 2 mm screen. NIR scans of these soils were made with a NIR systems 6500 scanning spectrophotometer, obtaining spectra at 2 nm intervals between the 400 and 2500 nm wavelengths.

The soils were ranked for ESP or pH on existing soil test data and a subset consisting of every fourth sample removed. The remaining samples were used to create NIR calibrations for sodicity (ESP) and pH. The subset soil samples were used as a verification set to determine the predictive ability of the calibration. Initial calibrations were developed for sodicity and pH and the verification sets applied to the calibrations. Calibrations were also developed for other soil properties and appear promising for total CEC, Ca, Mg and Ca:Mg ratios.

For the surface soils the best predictive ability was achieved for CEC with $r^2 = 0.90$ and SEP of 1.9 meq $100g^{-1}$. pH ($CaCl_2$) and exchangeable Ca and Mg were also predicted well by the NIRS with $r^2 \geq 0.80$ and SEP's of 0.31 pH units, 1.3 and 1.1 meq $100g^{-1}$ respectively. Other soil constituent predictions were Ca:Mg ratio and exchangeable Al, $r^2 \geq 0.70$, ESP, OC%, Na and K with $r^2 > 0.6$, and Al% with $r^2 > 0.5$. EC and P were very poorly predicted with $R^2 < 0.4$.

For the subsoil data sets the best predictive ability was achieved for exchangeable Na, CEC and ESP with $r^2 \geq 0.80$, and SEP of 1.13 meq $100g^{-1}$, 2.74 and 4.28 units respectively. Ca:Mg ratio, exchangeable Mg and K, and pH ($CaCl_2$) were also predicted well by the NIRS with $r^2 \geq 0.70$. Other soil constituent predictions were exchangeable Ca and EC with $r^2 \geq 0.60$ and exchangeable Al and Al% were very poorly predicted with $R^2 < 0.4$.

2.2 Crop management in relation to environmental change

Sub-Program Leader:
Mr Rob Williams
NSW Agriculture
Yanco

Temperature at the reproductive stage is the most important contributor to the yearly variation in grain yield, with cool night temperatures prior to flowering drastically reducing yields. The average commercial rice yield in 1996, for example, was only 6.5 t/ha, compared with the record 9.4 t/ha in 1998, with some crops in 1996 yielding less than 1 t/ha – a devastating result for those growers. Irrigation water is used to protect rice from cold. It is recommended that water depths be increased to at least 20 cm during the sensitive developmental phase to maintain the temperature of the developing panicle. This requirement limits the options for alternative water application regimes.

Cold at the reproductive stage particularly affects pollen development. The most sensitive stage is understood to be the early microspore stage, just following pollen mother cell meiosis when single pollen grains are just beginning to fill with starch.

Rice CRC projects are particularly aimed at understanding and eventually improving the response of rice to cold at the reproductive stage.

Cold physiology at the plant level (2201)

Project Leader:
Mr Rob Williams
NSW Agriculture
Yanco

Objectives

The aim of the project is to identify low temperature tolerant rice varieties in the glasshouse and field environments by developing a screening technique at flowering.

Progress

* *Industry Model*

An Australian Rice Industry Model (ARIM) has been developed in this Sub-Program. ARIM uses seasonal weather data to predict the future rice crop as well as estimating historical levels of low temperature damage. Prior to harvest ARIM successfully predicted the record rice yields of 10.1 t/ha for Amaroo in the 2000/2001 harvest (with an error of 0.4 t/ha). The record industry yields of 9.5 t/ha was reached following warm vegetative temperature, high levels of solar radiation and little reproductive low temperature damage. Ricegrowers' Co-operative Limited used ARIM's in-season prediction to determine storage and handling operations of the record 1.75 million tonnes.

* *Field Trials*

Field trials at Yanco, NSW aimed to confirm the cold tolerance in the field of lines known to differ in previous temperature controlled experiments. Two permanent areas for continued cold tolerance testing have been established at Yanco Agricultural Institute. Each has seven smaller bays in an area of one-tenth of a hectare. The 2000/2001 field trial at Yanco used seven sowing dates staggered from October 30 to December 19, 2000. Seven cultivars from different origins and levels of cold tolerance were replicated in each bay. Three nitrogen rates (0, 150 and 300 kg N/ha) were applied prior to permanent flooding to increase the likelihood of increased spikelet sterility. The mean temperature from November 1, 2000 to January 31, 2001 was 24°C, which was the second warmest since 1955. Therefore there was limited low temperature damage during the reproductive stage in the 2000/2001 field trial. Spikelet sterility was induced in the early flowering cultivar HSC55 in the first three sowing dates as a result of low temperatures of 9°C between December 20-25, 2000. Cooler night temperatures during late February caused spikelet sterility in the sensitive cultivar Doongara in the final two sowing dates.

* *Screening cultivars with cool water*

The use of cool water to screen cold tolerant cultivars has been a success in countries such as Japan and Korea, but has never been tested in Australia. A new cool water system was developed for the 2000/2001 rice season at a neighbouring property to Yanco Agricultural Institute. Cool water was diverted from a spearhead bore (20 metres depth) continuously flushing an insulated tub to maintain temperature at 18.7°C.

Eight cultivars of known tolerance were established in a glasshouse and moved into the cool water system where water was maintained 40 cm deep. All plants were subjected to cool water for 25 days until flowering. Cool water treatment significantly reduced anther length, anther area and number of engorged pollen grains at flowering. Strong correlations between these floral characters and spikelet sterility suggest that cold tolerance of cultivars can be identified prior to harvest. The total number of engorged pollen grains in the control and after cold water treatment for all cultivars was strongly correlated with spikelet sterility. Importantly there was agreement for cultivar tolerance after both cool air and cool water screening. The opportunities that exist for cold tolerance screening with deep cool water at the reproductive stage are now being considered.

* *Glasshouse Trials*

A temperature controlled experiment was conducted to test the cold tolerance of 216 lines from crosses between Millin, Illabong, HSC 55 and Plovdiv 22. HSC 55 (Hungary) and Plovdiv 22 (Bulgaria) have been identified in previous experiments as being cold tolerant. The day/night temperature of 24/12°C induced adequate sterility to identify transgressive segregating lines.

* *Trip to Cambodia and Laos*

Mr Tim Farrell (project researcher) attended the international conference on "The Impact of Agricultural Research for Development in South-East Asia", in Phnom Penh, Cambodia, October 24-26, 2000. Mr Farrell was an invited scientist in an ACIAR workshop on "Productivity of Lowland Rice in South-East Asia – Overcoming Environmental Constraints", in Vientiane, Laos from October 30 to November 1, 2000. One of the highlights of the trip was the discussion with fellow international scientists on three distinct research areas including cold tolerance, drought tolerance and soil fertility management. Mr Farrell presented a paper titled, "Low temperature constraints to rice production in Australia and Laos: a shared problem". The paper focused on temperature constraints during vegetative and reproductive growth, making some useful recommendations for growers and researchers to reduce the threat of low temperature damage. The ACIAR international workshop contributed to understanding the production systems in Laos, specifically the rain-fed lowland and irrigated dry season rice environments.

Mr Farrell recommended that continued collaboration with researchers from Japan, Korea, IRRI, Laos and Cambodia should continue through the joint ACIAR project. This collaboration should include the sharing of knowledge and germplasm exchange.

* *Germplasm exchange*

Germplasm transfer and evaluation is important to overcome environmental constraints in rice growing areas throughout the world. There has been exchange of promising lines amongst Cambodia, Laos and Australia. In the 2000 rice season ten promising cold tolerant cultivars were sent by Mr Farrell and sown in the field trials at Laos. Mr Farrell is looking forward to seeing the results of cultivars grown under different environmental conditions in Laos. Twenty cultivars from Laos have arrived in Australia and Mr Farrell will be assessing their level of cold tolerance.

New cold tolerant cultivars have recently arrived from Japan. These include Jyoudeki, Norin 8 and Norin 11, which were identified as cold tolerant following testing using deep cool water. These cultivars will be tested for tolerance under Australian conditions.

Cellular biology of chilling induced pollen damage in rice (2203/2204/3202)

Project Leader:
Dr Bruce Sutton
University of Sydney
Sydney

These projects have been transferred to Sub-Program 3.2 (3202). See Program 3 report.

Effect of nitrogen and low temperature on reproductive development (2205)

Project Leader:
Dr Shu Fukai
University of Queensland
St Lucia

Objectives

The aim of the project is to investigate the effects of nitrogen and low temperature on the reproductive development and spikelet sterility in rice.

Progress

The highly unpredictable nature of occurrence of low temperature during microspore development (early pollen development), irrespective of the sowing time, raised difficulties in investigation of the effects of N and low temperature on grain yield. Glasshouse experiments designed to control air temperature and water depth and temperature investigated in this project have been more important, with field experiments providing supporting evidence on the mechanism of N by low temperature interaction on spikelet sterility.

The critical microspore development period of the early October sown crop in the field experiment of 1999/2000 coincided with the average minimum temperature <13°C, while similar development stage of a late sown crop was observed during the period of relatively warmer minimum air temperature. In both early- and late-sown crops pollen production was greater in deep- than in shallow-water bays. Both the low night temperature and reduced pollen production increased spikelet sterility. Low temperature during microspore development in the early-sown crop also decreased grain yield but deep water reduced the effect.

Outcomes

Although application of N increased spikelet density, it also decreased pollen production. Both the greater spikelet density and reduced pollen production resulted in increased sterility. The total pollen production (or the number of microspores) is determined by panicle temperature while the proportion of engorged pollen which is a key component for spikelet fertilisation, is determined by both panicle and root temperature.

2.3 Mineral nutrition and grain quality

Sub-Program Leader:
Prof Graeme Batten
Charles Sturt University
Wagga Wagga

Rice yield, grain quality and human nutrition are all influenced by the minerals available to roots and taken up by the plant. There are indications from intensive rice farms in the Murrumbidgee Irrigation Area (MIA) that mineral deficiencies may be impacting on some quality attributes. A better basic understanding of factors which influence the uptake and translocation of nutrients within the rice plant, especially to the grain, will place the industry in a better position to sustain rice yield potential and compete for markets which use grain quality and nutrition standards.

The projects aim to gain a basic understanding of the factors which influence the uptake and translocation of minerals and their impact on production and quality. The staff is comprised of three scientists, two technical officers, one postgraduate student and one honours student.

Rice plant nutrition and physiology (2301)

Project Leaders:
Prof Graeme Batten
Charles Sturt University, Wagga Wagga
Dr Lindsay Campbell
University of Sydney, Sydney

The trace elements iron and zinc are receiving attention from plant and human nutritionists.

Objectives

In this project Mr Rob Duncan aimed to establish links between trace element distribution in the rice plant and grain quality, as part of a higher degree. Mr Duncan has completed his project work with the CRC and is currently completing writing of his thesis.

Progress

Based on reports at the International Rice Research Institute (IRRI), Philippines, a number of lines of rice were imported to evaluate their potential for having grain with high concentrations of iron and/or zinc. Lines were grown under quarantine at Eastern Creek (near Sydney, NSW); two Australian cultivars (Langi and Namaga) were also grown in the quarantine greenhouse for comparison. Leaves were sampled at anthesis and analysed for minerals. "Tong Lan Mo Mi" had the highest leaf iron concentration but had one of the lowest zinc concentrations. Langi had the highest zinc concentration in the leaves at anthesis.

Of the lines that flowered and set grain, line "CT" had the highest grain weight, out-performing both Langi and Namaga by 15%. These cultivars had the highest iron concentrations in the grain. However, Namaga had a slightly higher iron concentration than "CT". "CT" had the highest zinc concentration in the grain of any of the lines tested. The Australian cultivars had about the same zinc concentration as most of the other imported lines.

Concentrations of the other nutrients in the grain did not follow the same patterns. Thus selection of a line for a given nutrient does not mean that other nutrient concentrations are correlated.

This experiment also demonstrated that lines imported from IRRI did not behave as predicted. It implies that lines will need to be evaluated in the environment in which they will be grown.

Mineral requirements (2302)

Project Leader:
Prof Graeme Batten
Charles Sturt University
Wagga Wagga

Objectives

The aim of the project is to understand the factors which link minerals and quality in grains.

* ***Low phytic acid rice***

Progress

A low phytic acid mutant (lpa-1) of the rice cultivar "Kaybonnet" has recently been identified in the USA. Seed of this lpa mutant and its parent was imported into Australia and increased in a controlled environment. As part of a fourth year honours project at the University of Sydney, Ms Briony Wiltshire studied the influence of the low phytic acid gene on nutrient accumulation during grain filling and the plant response to high and low levels of nutrient supply.

The concentration of nutrients in the grain increased over the first 20 days after anthesis and remained relatively constant thereafter to maturity. Under low nutrient supply, lpa had proportionally lower grain weights than the control cultivar "Kaybonnet" but maintained a relatively stable concentration of phosphate in the grain. The concentration of potassium in the grain decreased under nutrient stress. When high levels of phosphate were supplied, grain phosphate concentration increased slightly.

Seed of Kaybonnet and the lpa mutant was grown in the field in the 2000/2001 season to increase seed reserves. Based on small plot yields, it is suggested that the parent and mutant yield about 7-8 t/ha. Samples of the seed harvested in 2001 are being analysed to determine mineral composition and assess the distribution of minerals in bran and endosperm layers.

Wild relatives of rice

Project Leader:
Prof Graeme Batten
Charles Sturt University
Wagga Wagga

Objectives

The objective of this project is to review the characteristics of wild relatives of rice that may enhance or impact on the sustainability of rice cropping. A literature survey has been undertaken of more than 500 references on the wild relatives of rice including 12 species of *Oryza* and four related genera.

The review will scope the range of work undertaken in terms of taxonomy, genetics, agronomy, nutrition, physiology, breeding, distribution and ecology; to ascertain if useful traits have been identified in wild rice that ultimately may be beneficial in *O. sativa* lines.

Three species of wild rice have been identified in Australia. They are *O. rufipogon*, *O. meridionalis* and *O. australiensis*. *O. rufipogon* is a strongly photoperiodic species and thus may not pose a great threat as a weed to the existing industry unless crossing occurs. If the rice industry expands to northern Australia, these species may become significant weeds. *O. rufipogon* sheds seed readily and has been crossed with a line of *O. sativa*. *O. australiensis* is highly susceptible to rice root rot nematode (*Meloidognye graminicola*). The concern is that *O. australiensis* could harbour this nematode that may damage cultivated rices.

Investigating links between minerals in rice grain and straighthead (2303)

Project Leader:
Mr Phillip Williams
Ricegrowers' Co-operative Limited
Leeton

Objectives

The aim of the project is to find factors that cause straighthead and determine the impact on grain quality.

Progress

Samples from a previous survey indicated straighthead is obvious in patches of affected crops but the ratio of grain to total shoot weight suggested that there are areas in crops with reduced yield but no visible symptoms of straighthead are evident. Yield reduction appears to be associated with increases in the concentration of minerals in the grain.

Table 1: Comparison of some minerals in grain samples taken from rice crops which appeared normal or showed visible symptoms of straighthead.

	1999	1999	1998	1998
	Brown Rice	Brown Rice		
Minerals (mg/kg)	Straighthead	near Straighthead	Brown	Milled
P mg/kg	3500	3010	2770	930
Mg mg/kg	1490	1290	1090	220
S mg/kg	790	720		
Ca mg/kg	94	94	91	46
Zn mg/kg	25	17	17	12
Fe mg/kg	14	9.9	11	2.5
No. samples =	18	16	24	24

Links with Program 2.2 are considering the influence of incorporated stubble on the soil redox potential as a possible reason for straighthead in rice crops.

Optimising a nutrient solution for rice

Project Leader:
Dr Lindsay Campbell
University of Sydney
Sydney

Mr Jeff McCormick (a fourth year honours student at the University of Sydney) was appointed to this project on an honours scholarship in 2001.

Objectives

* To compare the growth of rice in different hydroponic solutions.

* To optimise the composition of a nutrient solution for growing a range of rice genotypes.

Progress

Members of the Rice CRC have found that hydroponically grown rice often suffers from poor vigour, evidence of deficiency symptoms and plant death.

Initial experiments with three cultivars (Amaroo, Langi and Peldi) used the standard Sydney solution that was based on a Johnson's solution. It was hypothesised that serial dilutions of this nutrient solution would not affect the growth, until very low solution concentrations occurred, as the ratio of nutrient concentrations remained constant. This hypothesis was falsified: dilution of the solution caused early onset of a nutrient deficiency. This deficiency was subsequently shown to be iron. It was also hypothesised that individual cultivars would respond differently to a specific nutrient solution. This hypothesis was proven to be false, as there was no significant difference in growth between the cultivars.

Several different solutions were tested on the cultivar Amaroo to ascertain the response to the solution. The standard Sydney solution and a solution designed by IRRI proved to be the best. This also showed that rice was capable of growing in a solution at a pH as low as 4. Thus one of the aims of the project has already been fulfilled.

Rice is known to be high in silica. Addition of silica in the form of sodium silicate improved the rigidity of the leaves but did not alleviate impaired vigour, or the onset of nutrient deficiency symptoms.

2.4 Sustainable crop protection

Sub-Program Leader:
Dr Ric Cother
NSW Agriculture
Orange

Biological control of weeds and insects offers another control method for growers and, when implemented, ensures a longer life span for existing chemicals by reducing their use. Sustainability of modified, existing practices is enhanced by assisting to combat the development of resistant pest populations.

Host range and virulence of Rhynchosporium alismatis (2401)

Project Leader:
Dr Ric Cother
NSW Agriculture
Orange

This is a PhD project undertaken by Mr Wayne Pitt and aims to expand the host range of *Rhynchosporium alismatis*, a potential biological control agent for Alismataceae weeds in rice fields.

A protocol, developed during the sabbatical leave of a Canadian scientist funded by the CRC in January 2000, is being employed to transform the fungus with a cutinase gene construct obtained from *Fusarium oxysporum* f.sp. *pisi*. For fungal pathogens that infect plants by direct penetration of epidermal layers, digestion of the cuticle layer by hydrolytic enzymes, such as cutinase, is involved. Introducing cutinase genes into this fungus may enhance the ability of the fungus to penetrate the cuticle and therefore to reduce the required dew period, increase the efficacy of the agent in weed control and possibly expand the host range.
In addition, research is aimed at transforming the fungus with the SNF1 gene, believed to be involved in the regulation of production of cell wall-degrading enzymes. By increasing the copy number it may be possible to increase the production of multiple enzymes involved in cell wall degradation. An alternative approach to isolation and introduction of individual genes would be to identify the genetic regulatory elements for which insertion into the pathogen results in an increase in the production of multiple enzymes. If a mutant is globally enhanced in its ability to make multiple cell-wall degrading enzymes, the ability of the fungus to enter the plant would theoretically be enhanced.

Outcomes

Enhanced understanding of the infection process of Alismataceae weeds and potential for widening the host range of *R.alismatis*.

Improving crop protection (2403)

Project Leader:
Dr Ric Cother
NSW Agriculture
Orange

The CRC assisted French scientist, Dr Sophie Cliquet, from the Université de Bretagne Occidentale, to work in Australia during sabbatical leave supported by an OECD Fellowship. From December 2000 to May 2001, she studied the development of an inundative bioherbicide based on chlamydospores of *R. alismatis* at the School of Science and Agriculture, Charles Sturt University, Wagga Wagga. She examined the optimum range of carbon and nitrogen sources and carbon-nitrogen ratios and concentrations that will support a high yield of chlamydospores in liquid culture. Chlamydospores have potential to be a more robust inoculum for infection of Alismataceae weeds. This project has enabled valuable international linkages in pathogen biology and formulation to be established.

Dr Gavin Ash, CSU, Wagga Wagga, attended the NATO Advanced Research Workshop "Enhancing Biocontrol Agents and Handling Risks" in Florence, Italy in June 2001. Dr Ash was able to accept the invitation with travel support from the CRC. This pre-eminent meeting examined strategies for improving biocontrol agents as more attention is focused worldwide on these control methods.

Sustainability of rice production systems (2405)

Project Leader:
Dr Mark Stevens
NSW Agriculture
Yanco

This project involves two postgraduate study programs on (1) the influence of barnyard grass herbicides on non-target invertebrates, and (2) the ecology of mosquitoes in rice fields and associated habitats.

Progress

The first program, an honours project conducted by Ms Ayesha Burdett, concluded in April 2000. Ms Burdett has since graduated from the University of Melbourne with first class honours and enrolled in a PhD program at CSU. The results of her project, which demonstrated the adverse effects of thiobencarb on invertebrate communities, have been accepted for publication in *Environmental Toxicology and Chemistry*.

The mosquito project is being conducted as an MSc(Med) degree by Ms Liesl Schiller. Field work concluded in March 2001, and her thesis is currently in preparation. Her results demonstrate that high levels of mosquito production only occur in rice fields for a limited period each season and indicate that high predator densities may be responsible for limiting mosquito emergence. The efficiency of these predators varies in response to the size and

structure of alternative prey populations. Ms Schiller's project is co-supervised by Assoc Prof Richard Russell of the University of Sydney (Westmead Hospital).

Biodiversity assessment of MIA rice fields using stable isotope analysis (2406)

Project Leader:
Dr Mark Stevens
NSW Agriculture
Yanco

This study is being conducted by Ms Andrea Wilson as part of her PhD program at Charles Sturt University. The objective of the project is to determine whether there are differences in aquatic food web structure between conventional and organic cropping systems.

Progress

All isotope assessments have now been completed and preliminary results were presented at the British Ecological Society Meeting, Birmingham, in January 2001. The data shows that the three-tiered food web structure that occurs in organic systems is far more loosely structured in conventional crops. This instability is presumably a consequence of pesticides used in the conventional crops having a particularly detrimental effect on organisms near the base of the food chain.

Ms Wilson's thesis is due for completion in December 2001.

Risk assessment of exotic plant diseases to the Australian rice industry (2407)

Project Leader:
Dr Gavin Ash
Charles Sturt University
Wagga Wagga

Objectives

The Australian rice industry has enjoyed a lifetime of freedom from serious diseases mainly because of its isolation from the other rice growing countries. The introduction of new diseases is quite possible because more than 30 diseases can be transmitted on or inside rice grains. The objective of this project was to assess the risk rice blast and other exotic diseases represent to the Australian rice industry in the event of a hypothetical introduction.

Progress

A disease risk assessment of bacterial, fungal, viral diseases and nematodes was conducted using all the available information in the literature. Two software programs developed by CSIRO, CLIMEX and DYMEX, were also used in this disease risk assessment. CLIMEX was used to assess the suitability of the Australian rice growing area climate for each disease

and, when possible, a disease model was created under DYMEX and ran with Australian climatic data.

Rice blast has never been observed on rice in New South Wales (NSW) but its causal agent, *M. grisea* has already been reported on weeds in several coastal regions of NSW. Several Australian strains of *M. grisea* were tested on Australian rice cultivars in quarantine glasshouses to determine if they could infect our rice varieties.

A disease survey covering most rice growing areas in NSW was also undertaken. During the rice disease survey individual farmers as well as farmer groups were presented with the work conducted on rice blast. The poster "Could rice blast occur in Australia?" has also been presented to growers attending NSW Agriculture rice field days.

Outcomes

The Australian climatic conditions and/or the rice growing practices were found to be unfavourable for most exotic rice diseases. However, two diseases of rice (rice blast and kernel smut) and one plant parasitic nematode genus (root nematodes) were identified as having the potential to become established in the Australian rice growing area if ever introduced in South-Eastern Australia.

A rice blast (caused by *Magnaporthe grisea*) model has been successfully developed and validated. According to the model, rice blast could occur in South-Eastern Australia. Our rice blast model was run for the period 1988-1999 with the meteorological data of four representative locations in the Australian rice growing region. Out of a possible 11 rice growing seasons, the number of years favourable for *M. grisea* ranged from two at Griffith (NSW) to nine at Yanco (NSW). Preliminary results indicate that the Australian isolates of *M. grisea* are unable to infect rice.

The rice disease survey revealed the presence of a new fungal disease called aggregate sheath spot (caused by *Rhizoctonia oryzae-sativae*) and confirmed the presence of the fungal disease sheath spot (caused by *Waitea circinata*).

2.5 Economics

(This Sub-Program relates to projects across all of the CRC's Programs).

Evaluation of alternative resource management strategies in a risky environment (6201)

Project Leader:
Dr Rajinder pal Singh
NSW Agriculture
Yanco

Objectives

This project aims to evaluate a selection of Rice CRC research and extension projects against economic and physical dimensions of sustainability. The project involves analysing the impact of selected CRC technologies at the farm and regional levels. This will identify changes in farm and regional incomes and changes in physical dimensions of sustainability such as soil and water salinity, and watertable depths.

The project involves assessing the economic consequences of the following CRC projects:-

* On-farm impacts of water reforms;

* Crops after rice;

* Reliability of production;

* Nitrogen application test.

Progress

Working closely with researchers working on the Rice CRC Project 2101 (A Strategic Soil Nitrogen Test for Flooded Rice), an analytical framework has been developed using the Decision Analysis TreeAge® software package that will help measure the benefits of the Near Infa-Red (NIR) tissue and soil tests. The initial financial analysis of the projects on reliability of production and crops after rice has been completed. A whole farm linear programming (LP) model is being developed. The model will be used to measure the on-farm impacts of water reforms, crops after rice, and the on-farm channel seepage control projects. An economic research report, using information from the Murrumbidgee Irrigation Area (MIA) representative farm model, is being prepared.

The representative farm models for both the MIA and Coleambally Irrigation Area (CIA) have been completed. The MIA representative farm model was presented in the Rice CRC Symposium 2000/2001. Using this information, an economic research report on the MIA is being prepared, which includes:-

* a description of the key management issues in the MIA rice-based farming systems;

* a description of the representative whole farm; and

* an analysis of the impact of different cropping rotations on whole farm returns.

A linear programming model is being developed by adapting the existing whole farm LP models developed by economists who were previously at NSW Agriculture's Yanco Agricultural Institute. The model will be completed shortly.

MILESTONES

	Milestone	Year 1	Year 2	Year 3	Year 4 - 2000/2001	Yr 5	Yr 6	Yr 7
2.1	**Soil chemical & physical properties**							
	Appointment of post doctoral fellow	X 4						
	Development of N soil test	X Commenced	X 4	X 4				
	Appointment of technical officer	X Modified						
	Soil acidity problem definition	X Acid soils program	X 4	X 4	X 4			
	Definition of soil property damages	X Commenced	X 4	X 4	X 4	X	X	X
	Evaluation of aerial video as a tool			X 4	X 4	X	X	X
	Definition of management factors affecting nutrient recovery			X 4	X 4	X	X	X
	PhD project - spatial analysis	X Commenced	X 4	X 4	X 4	X	X	X
2.2	**Environmental change**							
	Appoint research scientist	X 4						
	Define flowering test for cold resistance	X Commenced	X 4	X 4				
	Confirm tolerance under field conditions	X Commenced	X Continuing	X Continuing	X 4			
	Student projects	X One appointed	X 4	X 4	X 4			
	Understanding cold and Nitrogen interaction	X Commenced	X 4	X 4	X 4	X		
	Lipid metabolism	X Program modified	X Suspended - will recommence in Year 3 as modified project	X Suspended	X Redefined			
	Understanding cellular response to cold	X Commenced	X 4	X 4	X 4			
	Application of cold studies			X 4	X 4	X	X	X
	Studies on climate change			X 4	X 4	X	X	X
2.3	**Mineral nutrition**							
	Appointment of staff	X Commenced	4		X 4			
	Appointment of student	X Not achieved	4		X 4			
	Review of factors affecting yield and quality	X Commenced	X 4	X 4				
	Development of techniques	X Commenced	X 4	X 4				
	Assess mineral changes	X Commenced	X 4	X 4				
	Assess impact of yield improvement and management changes on mineral/quality relationships in rice and its relatives	X	X 4	X 4				
	Determine mechanisms influencing translocation of mineral to grain			X Commenced	X 4	X	X	X
	Modify factors influencing quality in intensive rice growing			X Commenced	X 4	X	X	X
2.4	**Sustainable crop protection**							
	Appointment of PhD student	X 4			X 4			
	Appointment of honour students	X Replaced by visiting scientist			X 4			
	Biology of Arrowhead and Water Plantain	X RIRDC projects	X RIRDC projects	X RIRDC projects				
	Better understand biocontrol	X 4	X 4	X 4				

	Milestone	Year 1	Year 2	Year 3	Year 4 - 2000/2001	Yr 5	Yr 6	Yr 7
	Identification of dominant bloodworm species	X Commenced	X 4					
	Develop lab techniques for at least 1 additional Chironomid		X Commenced	X Commenced	X 4			
	Evaluate Bti* transgenic lines		Staff appointed	X 4	X 4	X	X	X
	Allelopathy	X With Program 3	X Program 3	X Program 3				
	Progress towards identification of allelochemicals	X	X Program 3	X Program 3				
	Improved pathogenicity of *R.alismatis* to Alismataceous weeds				X 4	X	X	X
	Phenology and host specificity of bloodworm species defined				X reallocated	X	X	X
	Integration of chemical and biological management of weeds				X 4	X	X	X
	Determination of susceptibility of major cultivars to exotic pests and diseases				X 4	X	X	X

*Bti= *Bacillus thuringiensis*, a bacterium with insecticidal properties.

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

4= Achieved (if not achieved, status provided.)

PROGRAM 3

GENETIC IMPROVEMENT FOR SUSTAINABLE PRODUCTION

Program Leader:
Dr Liz Dennis
CSIRO Plant Industry
Canberra

Research in Program 3 combines traditional breeding and physiology with newer molecular techniques to improve the genetic base of the Australian rice crop. Australia's rice industry already produces a high yield. Our aims are to increase this yield further and to overcome specific problems such as reduction of yield through low temperatures.

Traditional breeding approaches include the evaluation of new lines from other countries with the characteristics of shorter duration life cycle. Advanced physiological approaches to breeding involve screening rice lines for improved yield potential using stomatal aperture traits, which may result in improved water use efficiency or other desirable attributes.

One of the main elements of Program 3 is the identification of the cellular and molecular characteristics responsible for cold induced pollen sterility. This project has been extended to include identification of all of the genes up and down regulated by cold during microspore development. Cold induced changes in the spectrum of proteins made in microspores during pollen development are being studied, as are the cellular changes that occur when cold stress is applied. These molecular and cellular approaches complement the work in Program 2 which takes a more physiological approach. We thus have a comprehensive approach to one of the major limitations to yield in the Australian rice industry.

Advanced tissue culture techniques are being developed which may assist breeding objectives. Microspore culture of a number of rice lines has been achieved. Tissue culture of developing pollen is providing material to study the effects of cold.

Tolerance to biotic stress is another objective of the program. Genes conferring resistance to bloodworm have been identified and are being introduced into rice so as to decrease the need for pesticides for controlling bloodworm. Varieties that can suppress the growth of arrowhead, a major weed of Australian rice crops, by manufacture of phytotoxins have been identified and the chemicals responsible are being analysed.

Case Study

Measuring for consumer preferences

(M Fitzgerald and C Blanchard)

The Australian Rice Industry is recognised internationally as producing high-quality rice. In order to maintain that reputation, it is important to understand the basis of grain quality attributes and to ensure new varieties contain desired attributes. The amylose content is thought to be one of the most important things that determine quality.

Amylose content is measured in all breeding programs, but often varieties with the same amylose content do not perform the same way or as expected. In this project, we have attempted to measure amylose structure. We have developed a method to measure amylose structure and we have shown that varieties with the same amylose content differ in the structure of their amylose. We have also shown for these varieties that the gene responsible for the synthesis of amylose, granule bound starch synthase, differs.

By knowing that the sequence of granule bound starch synthase differs, the way is now open to investigate how these differences in the gene affect the action of the gene and how this flows on to affect the structure and function of amylose. By knowing that amylose structure differs among varieties of the same amylose content, the way is now open to investigate relationships between amylose structure and known cooking and processing properties. Function can then be assigned to structure and this knowledge can be incorporated into the rice breeding program. By understanding the synthesis as well as the function of the compounds in rice, the Rice CRC is delivering very powerful tools to the Australian rice breeding program that will significantly enhance its capacity to release varieties that meet the requirements of customers.

3.1 Improved yield efficiency

Sub-Program Leaders:
Dr Laurie Lewin and Dr Russell Reinke
NSW Agriculture
Yanco

Improved yield efficiency can be achieved through increased grain yield, by maintaining yield but reducing duration or a combination of both. The RIRDC-funded rice improvement program has improved yield potential and reduced duration as objectives. The CRC Sub-Program aims at novel approaches for development of this objective.

Improved yield efficiency (3101)

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

Objectives

To develop new sources of short duration and high yield potential to improve yield efficiency of Australian rice cultivars.

Progress

New cultivars were introduced from Hungary and Japan to provide new sources of early maturity. Additional introductions were made from Egypt to improve yield potential. Preliminary yield information on cultivars from Russia, Hungary and Japan indicate that these will be useful sources of short duration but that none combine the productivity, quality and duration to be useful as production varieties.

The Egyptian cultivars were increased to allow yield evaluation in the 2001/2002 season. Nine new crosses were made with Russian, Hungarian and Egyptian cultivars. Selections were taken from 20 F2 populations from similar crosses to produce lines with high yield potential, short duration and acceptable grain quality. These lines will be developed through the traditional plant breeding program.

3.2 Tolerance to abiotic and biotic stress

Sub-Program Leader:
Dr Liz Dennis
CSIRO Plant Industry
Canberra

The chief abiotic stress investigated in this Sub-Program is the molecular and cellular basis of cold induced pollen sterility, which can decrease rice yields by as much as 50% in bad years and by some percentage most years. The cellular and molecular approaches being investigated in Program 3 complement the physiological approaches in Program 2. Biotic stresses investigated include attack by bloodworm where a molecular approach is underway and weed competition where a number of rice lines are being screened for the ability to compete with weeds.

Molecular basis of cold tolerance (3201)

Project Leader:
Dr Liz Dennis
CSIRO Plant Industry
Canberra

Objectives

* To study the effect of cold on sugar metabolism in rice anthers.

* To study the effect of cold treatment on the expression of invertase genes in rice anthers.

* To investigate whether cold-induced changes in sugar metabolism are cause or consequence of pollen sterility.

Progress

* Gene constructs were made using the promoter of the rice anther apoplastic (*OSINV1*) and vacuolar (*OSINV2*) invertase genes, fused to a glucuronidase (GUS) reporter gene.

* All constructs were transformed into rice using *Agrobacterium tumefaciens* and transgenic rice plants were regenerated.

* Plants with the yeast invertase gene were produced, driven by the rice *OSINV1* promoter and two tapetum-specific promoters (tobacco *NIN88* and rice *OSgB6*).

* Transgenic rice plants are currently being analysed to detect the presence and copy-number of the transgenes.

* Sugar content and invertase enzyme activity measurements were carried out on rice anther material.

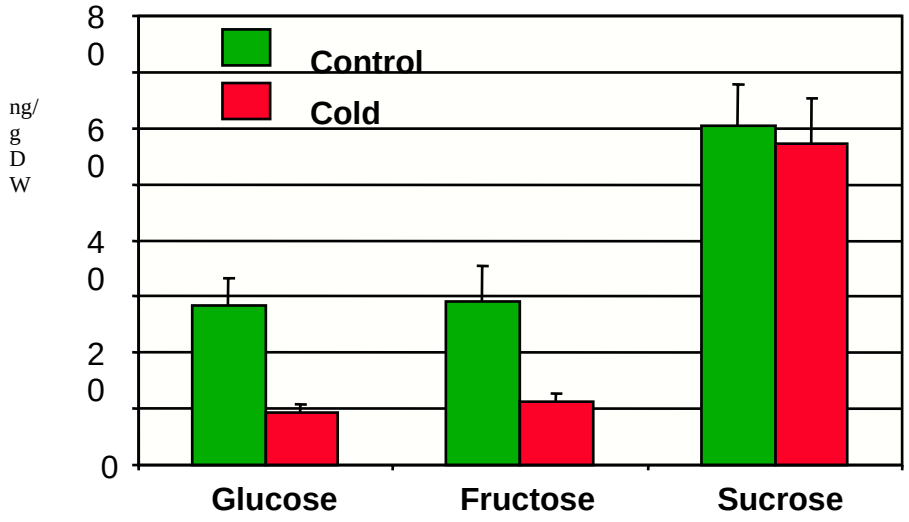
Outcomes

* Changes in sugar levels in cold-stressed anthers are one of the earliest biochemical changes observed in anthers.

* Investigation of invertase gene expression will enable the CRC to study the cold-induced changes in sugar downloading to pollen.

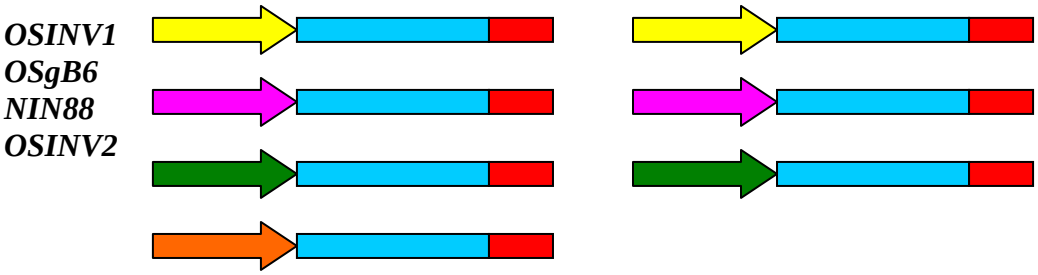
* By looking at the effect of cold on the function of sugar metabolic genes like invertase, the CRC will be able to study whether changes in sugar metabolism are cause or consequence of cold-induced sterility.

Cold treatment causes depletion of hexose sugars (glucose and fructose) in rice anthers.

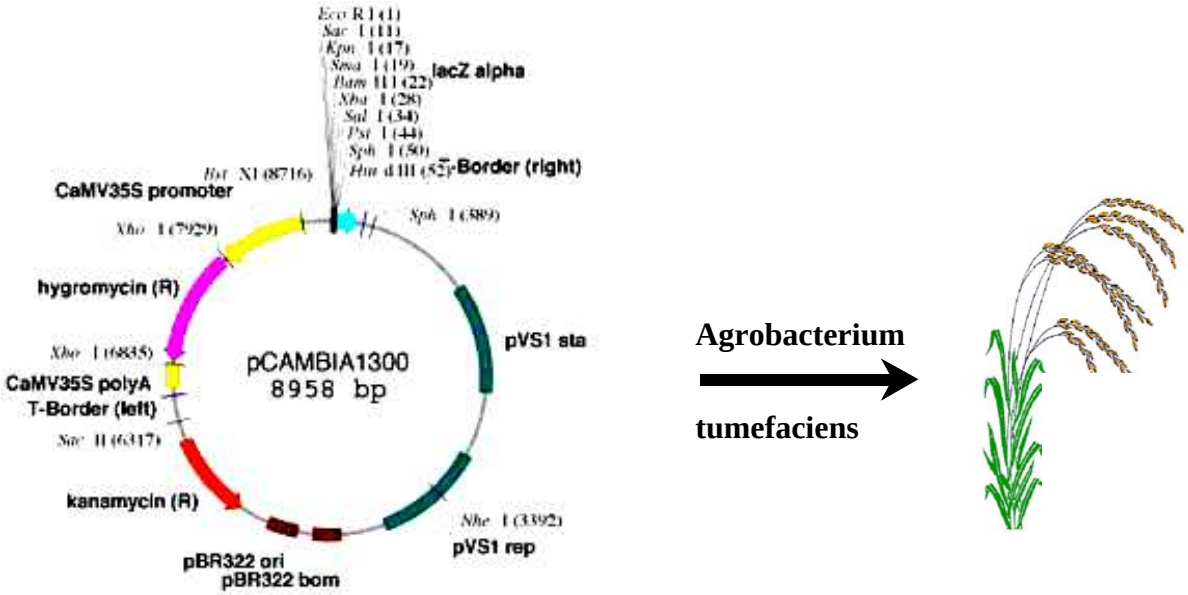


Chimeric gene constructs transformed to rice.

A.



B.



A: Gene constructs were made using the GUS reporter gene and the invertase gene from bakers yeast, fused to different tapetum-specific promoters (apoplastic invertase OSINV1, vacuolar invertase OSINV1, tobacco invertase NIN88, and rice OSgB6).
B:The constructs were cloned into binary vector pCAMBIA1300 and transformed to rice (Var. Doongara) using the bacterium Agrobacterium tumefaciens.

Cellular biology of chilling-induced pollen damage in rice (3202)

Project Leader:
Dr Bruce Sutton
University of Sydney
Sydney

Objectives

* To investigate the formation and dissolution of the special callose wall surrounding the developing meiocytes/microspores and to discover its fate during chilling episodes.

* To develop a tissue culture system capable of supporting individual rice florets through critical stages of development. The aim is to be confident that anthers isolated from the rice plant function normally during physiological studies.

* To map the pathways of symplastic assimilate transport within the anther after chilling treatments and to compare these to the patterns of transport observed in anthers grown at normal temperatures.

Progress

* Using electron microscopy and immunogold labelling, the CRC has some evidence that the special callose wall surrounding the meiocytes/microspores breaks down earlier in chilling-affected anthers. The pollen wall also fails to develop normally in chilled anthers and the two events might be linked.

* A tissue culture system that supports anthers through 12-hour segments of development from premeiosis through to early microspore stage has been devised. This system could be improved to permit the full developmental sequence to occur so that chilling experiments can be performed *in vitro*.

* Assimilates have the potential to move symplastically either part way through the anther support tissues to the endothecium/middle layer boundary or to the tapetum/locule boundary adjacent to this region of pollen formation. Both states have been observed after normal and chilling temperature treatments and more work is being carried out to clarify these observations.

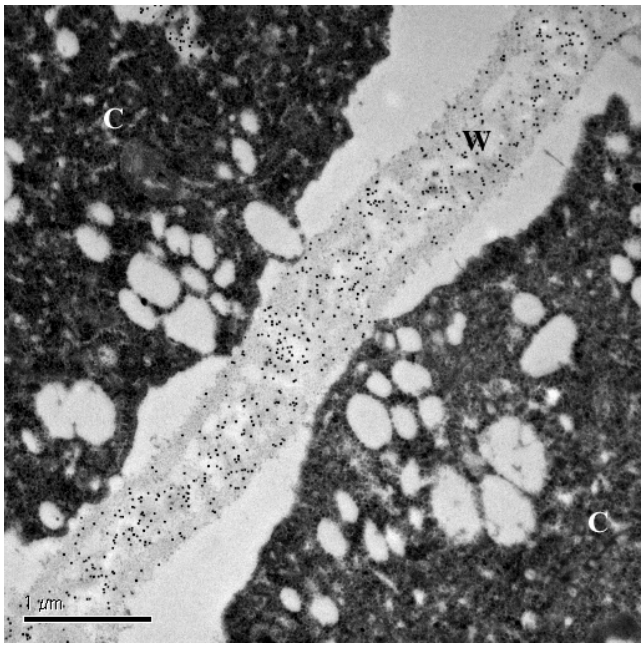
Outcomes

* Control of the special callose wall could be one of the fundamental processes affected by environmental stress. Currently we are looking at the localisation of one of the key enzymes involved in the breakdown of callose.

* The tissue culture system has allowed greater confidence in the in vitro physiological work that is being carried out on rice anthers. Difficulties encountered in developing a tissue

culture method for anthers has underscored the sensitivity of pollen development to any form of environmental change.

* Mapping of the symplastic pathways in rice anthers has provided a model for assimilate movement throughout the rice anther. It has also revealed some fundamental information about cell-to-cell communication in plant floral organs in general.



A callose wall between two dyad cells undergoing the second stage of cell division. The wall (W) that separates the two cells (C) is heavily coated with gold particles (black dots) indicating the presence of abundant callose at this stage.

Engineering rice for resistance to bloodworm (3203)

Project Leader:
Dr Liz Dennis
CSIRO Plant Industry
Canberra

Objectives

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. Specifically, the project aims to:-

* assess the potential for the control of chironomid larvae in rice paddies using transgenic rice expressing *Bacillus thuringiensis* sub-species *israelensis* (Bti) Cry toxin genes;

* analyse the interactions between the multiple Cry toxins in toxicity to *Chironomous tepperi*.

Progress

Bacillus thuringiensis sub-species *israelensis* (Bti) has six toxin genes (Cry 4A, 4B, 10A, 11A, Cyt 1A and Cyt 2B). The Cyt toxins are general cytolytic toxins that are far less specific for insects than the Cry toxins, so work on these genes has ceased. The Cry toxin genes are very unstable in *E. coli* when cloned as PCR products. So these genes have been isolated as large genomic clones by conventional methods. This has enabled the isolation of stable clones for Cry 11A, Cry 4A and Cry 4B. Expression of these clones is minimal in *E. coli* and so they have been transferred to Bt where much greater expression of the genes occurs. The Cry 10A gene is not expressed in Bt and so it is being altered to allow expression in Bt.

Approval for bioassay work to be performed with either *E. coli* and Bt expressed toxins has been obtained by Dr Mark Stevens at NSW Agriculture, Yanco. Preliminary data for the non-eecombinant toxin mixture from Bti suggests that the approach is feasible and that Cry 11A is the major chironomid toxin.

Constructs to express Cry 11A in rice are currently being made to determine the efficiency of expression of this gene in rice.

Allelopathy and weed competition (3205)

Project Leader:
Prof Jim Pratley
Charles Sturt University
Wagga Wagga

Objectives

Research conducted in the United States and the Philippines has demonstrated that a number of rice varieties have the ability to suppress the growth of certain weeds. The current project aims to:-

* screen a number of rice accessions from different countries for allelopathic capability against those weeds infesting Australian rice crops;

* identify and isolate the spectrum of phytotoxins responsible for the allelopathic effect;

* analyse implicated chemicals individually and collectively to identify new herbicide chemistries for development as natural herbicides; and

* determine the feasibility of incorporating allelopathic capability into rice varieties.

Progress

Allelopathy, a natural mechanism, could play a valuable role in an integrated weed management system, potentially reducing the amount of synthetic herbicides required for weed control. Research in a number of countries has suggested that a range of potential exists among rice varieties.

This project addresses the allelopathic potential of rice against arrowhead (*Sagittaria montevidensis*), a major weed in Australian rice crops, which has not been the focus of any prior allelopathy research. In an effort to locate rice varieties with this capability, 28 rice cultivars (including currently grown varieties such as Amaroo, Pelde and Kyeema) were screened for their effect on arrowhead root growth. Results varied from no effect to an almost complete suppression of root growth. This suggests that there is a genetic basis to allelopathic capability, providing the fodder for future breeding programs.

Chemical analysis of rice root exudates is currently being undertaken to identify the range of chemicals responsible for this observable allelopathic effect. The implicated chemicals will then be individually and collectively analysed to identify new herbicide chemistries.

Outcomes

* Varieties obtained from overseas - completed.

* Full screening of rice varieties for allelopathic potentia l- completed.

* Chemical analysis -commenced.

Characterisation of the developmental pathway of pollen maturation in rice anthers (3206)

Project Leader:
Prof Barry Rolfe
Australian National University
Canberra

Cytological studies were done on rice cultivar “Doongara” to investigate the correlation between microspore developmental stages and vegetative growth measurements. Based on this, anther samples were collected at six discrete developmental stages and protein contents were extracted and differentially displayed by proteome analysis. One hundred and sixty-five protein spots, which changed during the time course of development, were analysed by mass spectrometry and the identities of 25 of them were predicted by database searching. Some of these results were published in a research article from the group. Results were also presented as a poster display in the annual symposium of the CRC for Sustainable Rice Production.

The vacuolar acid invertase, -expansin, profilin and H+-ATPase, proteins that start to accumulate at late binucleate microspore stages and reach a very high level at heading stage, were identified with high confidence using the peptide mass fingerprint data. The appearance and accumulation of these proteins in the microspore are closely associated with sugar metabolism, cell elongation and cell expansion – cell activities essential to pollen germination.

Our findings support the sugar uptake model of pollen tube growth proposed Ylstra et al (1998).

Two low molecular weight proteins, which are preferentially expressed at very high levels from the binucleate microspore stage to the heading stage, were analysed by N-terminal micro sequencing to obtain N-terminal amino acid sequences. The two sequences matched 100% to two theoretically translated EST sequences from the Institute for Genome Research (TIGR) database and the theoretically calculated molecular weights and pIs of these two ESTs agree with those observed experimentally. In addition, pollen allergen domains were detected on both sequences. A homologue search using theoretically translated peptide sequences show that they share a low level of identity with group II pollen allergen from other plants. Antibodies to these proteins will be produced to investigate the functions of these proteins in the maturation of the male gametophyte and can be used as markers in assessing the stage of microspore development.

Reference: Ylstra et al (1998) Plant Physiol. 118:297-304.

Proteomic approaches to understanding molecular mechanism causing cold-induced sterility in rice (3207)

Project Leader:
Prof Barry Rolfe
Australian National University
Canberra

Rice *(Oryza sativa L.)* originated from tropical and sub-tropical areas and as a result it has characteristics of being vulnerable to cool weather. It is known that one cause of cold damage is pollen sterility. However, the underlying mechanisms that cause cold-induced male sterility are poorly understood. To investigate this, anther proteins at the early stages of microspore development have been extracted, with or without cold treatment at 12°C, and were separated by two-dimensional gel electrophoresis (2-DE). The cold sensitive cultivar "Doongara" and the relatively cold tolerant cultivar "HSC55" were used. We were able to resolve more than 4,000 rice anther proteins on a single 2-DE gel. Over 280 of these proteins were analysed, and over 80 of these were identified. This led to the construction of rice anther proteome databases that are available for public access at http://semele.anu.edu.au/2d/2d.html. Thirty-five proteins were identified as cold responsive proteins. Among them, the levels of 31 were up-regulated and three proteins were down-regulated. The levels of most of these proteins did not vary in either panicle samples or anthers of the relatively cold-tolerant cultivar HSC55 in response to cold treatment. This implicates these proteins as perhaps playing a role in the process of cold induced sterility and suggests mechanisms involved in cold damage.

Most of the cold responsive proteins were analysed and it was possible to identify nearly half of them. These identified cold-responsive proteins are involved in protein synthesis and folding, lipid biogenesis and cell wall formation, protein breakdown and energy metabolism. These functions are all potentially involved in processes that, if perturbed, may give rise to the effects seen with cold temperature treatment. These would affect mitochondria (and its inner membrane), endoplasmic reticulum, ribosomes and cell walls (exine formation), all of which have been observed to be affected by cold treatment. In the past, it was suggested that cold induced male sterility might be caused by disruption of sugar metabolism. However, our results indicate that there are a number of additional cell functions that are being varied by cold.

From these results, we are able to prepare two manuscripts for publication. The first one is in press *(Proteomics)* and the second one is being prepared for submission to the *Journal of Plant Physiology*. Thesis writing is now the predominant activity.

Identification of rice genes involved in cold-induced pollen sterility (3208)

Project Leader:
Dr Rudy Dolferus
CSIRO Plant Industry
Canberra

Objectives

* To use microarray (DNA chip) technology to identify rice anther genes affected by cold treatment.

* To use gene identification to unravel the biochemical and physiological processes that cause cold-induced pollen sterility.

* To identify key genes involved in cold-induced pollen sterility, and establish strategies to use these genes for genetic engineering or marker-assisted breeding for cold-tolerant rice varieties.

Progress

* 18,000 randomly selected cDNA clones from anther/panicle-specific cDNA libraries were transferred to microwell plates for frozen storage.

* The cDNA inserts from these 18,000 clones were amplified by PCR (Polymerised Chain Reaction).

* This amplified DNA was further purified by ethanol precipitation and verified by electrophoresis.

* The DNA is now ready for spotting on glass slides using a microarray robot.

* Rice plants were grown to produce anther material for the screening of the microarrays (different developmental stages, cold treatments).

Outcomes

* Microarrays can be used to identify rice anther genes that are affected by cold treatment.

* Identification of these genes and their function will lead to unravelling the biochemical and gene-regulatory processes that are at the basis of abortion of normal pollen development in response to cold spells.

* This may lead to the development of genetic engineering strategies for cold tolerant rice and the establishment of molecular markers for marker-assisted breeding.

Identification and characterisation of genes affected by cold treatment of rice anthers (3209)

Project Leader:
Dr Rudy Dolferus
CSIRO Plant Industry
Canberra

Objectives

* To analyse the effect of cold on the expression of the rice anther invertase genes (*OSINV1, 2*) using reporter gene constructs (GUS, GFP) and transgenic rice.

* To carry out expression studies at mRNA level of *OSINV1* and *OSINV2* and identify the effect of possible signalling mediators such as sugars and the plant hormones gibberellic acid and abscisic acid).

* To identify suitable candidate genes from the microarray project (3208) to carry out gene expression studies.

* To compare the spectrum of genes affected by sugar and plant hormone treatments with the genes induced by cold treatment on microarrays (DNA chips).

* To compare the response to cold of cold tolerant and sensitive varieties using DNA chips.

Progress

* A construct was made with the *OSINV1* promoter, including the apoplastic targeting sequence, fused to the cyan fluorescent protein (CFP) reporter gene. A similar construct is being made using the entire *OSINV1* coding region.

* A construct is being made for knocking out expression of the *OSINV1* and *OSINV2* genes in the tapetum cell layer of rice anthers (RNAi antisense suppression method).

* The rice zeaxanthin epoxidase gene was cloned. This gene encodes an enzyme of the ABA hormone biosynthesis pathway and will be used to produce a rice ABA deficient mutant using the RNAi method.

Outcomes

* Identification of the molecular mechanisms underlying the expression of anther genes in response to cold treatment will lead to a better understanding of what signalling events (sugars, plant hormones) are involved in inducing pollen sterility in response to cold.

* A better understanding of the signals that cause abortion of normal pollen development can lead to strategies to engineer cold tolerant rice varieties. Breeders aiming to select tolerant varieties in a breeding program can also exploit this information.

3.3 Enhancing the technology base for rice improvement

Sub-Program Leader:
Dr Norm Darvey
University of Sydney
Cobbitty

The successful microspore culture of japonica rice varieties “Taipai 309”, “Langi” and “Hitomebore” have been made in 2000. Several pre-treatments with anti-mitotic and cell synchronising agents are being tested on different rice varieties to improve culture response.

Development of a standardised system for controlled experiments on cold tolerance in rice is facing some difficulties in the culture of the young panicles and florets *in vitro*. The pre-meiosis panicle or floret did not undergo further development in culture. Many attempts have been made without success.

The hydroponic system is still performing very well to supply a large number of plants and panicles all year for both University of Sydney research groups (Plant Breeding Institute at Cobbitty and the Camperdown campus). New HQI (halogen quartz iodide) lights have been installed in the main rice growing greenhouse. This provided good lighting conditions to produce healthy plants during the winter months. This also enables uniform plant material to be produced through different seasons with controlled lighting and temperature.

Microspore and spikelet culture in rice (3301)/ Microspore culture of rice for rapid breeding and enhanced levels of interspecific recombination (3303)

Project Leader:
Dr Norm Darvey
University of Sydney
Cobbitty

* *Microspore culture*

Objectives

The aims of the project are to:-

* recover haploids via microspore culture (MC);

* apply MC technology to IRRI interspecifics carrying genes for cold tolerance, etc; and

* apply MC technology to materials from the national breeding program.

Progress

* *Microspore culture*

In 2000, microspore culture of Taipai 309, Langi and Hitomebore have been successfully isolated. A postgraduate student, Mr Manoj Gupta, was appointed to this project in July 2000. He subsequently resigned in February 2001 and the project is being carried on by Dr Xiaochun Zhao and Ms Feiyan Chen. The work is currently focussing on applying different anti-mitotic and synchronising agents to improve culture response. These agents have been identified to have positive effect callus induction in rice anther culture.

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

New HQI (halogen quartz iodide) lights have been installed in the main rice growing greenhouse. This lighting system provides nature and intensive lights for growing rice in winter. Large numbers of plants and panicles have been produced all year around for both research groups in Cobbitty and the main campus of The University of Sydney.

Culture of young panicles and florets *in vitro* was considered to be an ideal system in which to observe the physiological development of pollen under the microscope. This allows the critical stage of cold damage to be more easily studied. Successful culture of young panicles and florets at or after tetrad stage was achieved. Many attempts to culture microsporocytes prior to the tetrad stage using different media and plant growth regulators have failed.

Outcomes

* *Genetics of low temperature male sterility*

Differential Subtraction Chain (DSC) technique has been employed to study the genetic factors involved in low temperature male sterility. Some DNA sequences have been found to be switched off at low temperature during the booting stage in cold susceptible rice varieties “Doongara” and “Langi”. These unique DNA fragments have been cloned and sequenced. One DNA sequence from Langi has been found 88.3% identical to the barley glyceraldehyde-3-phosphate dehydrogenase cDNA sequence and 80.4% identical to a rice glyceraldehyde-3-phosphate dehydrogenase cDNA sequence. Another DNA sequence from Doongara showed 70% identity to a DNA sequence from CUGI Rice BAC Library. Confirmation of these results and conversion of these sequences into DNA markers are being carried out.

To progress development of DNA markers for cold tolerance rice breeding, a cross has been made between a cold susceptible variety “Doongara” and a cold tolerant variety “M103”. The anthers from F1 generation of this cross have been cultured to produce haploid plants. Over

50 haploid plants have been produced so far. This doubled haploid population will be examined for cold tolerance in the glasshouse and used for testing DNA markers.

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 as the factors that influence it are not fully understood. 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 amylose structure: what it controls and what controls it (3402)

Project Leader:
Dr Melissa Fitzgerald
NSW Agriculture
Yanco

Objectives

This project aims to:-

* develop a proven, reliable method to measure the structure of amylose chains;

* understand the effect of amylose structure on the swelling and gelation of starch granules;

* understand 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

* understand some of the factors that control amylose structure at the genetic level.

Progress

Progress has been made in understanding what controls amylose in three different varieties of rice, all of the same amylose content. Koshihikari, Millin and Amaroo were chosen since although each has a different allele of the amylose gene they all have the same amylose content.

The amount of amylose that solubilises during cooking is controlled by fats, proteins and the amount of soluble amylopectin. Searches of the literature have not revealed references to solubility of amylopectin and different varieties differ in the amount that becomes soluble.

The soluble fraction of the amylopectin is structurally different to the rest of the amylopectin. It does not become soluble until most of the amylose that solubilises has done so.

The molecular weight distribution of amylose from the three varieties differs and the structure of the amylose also differs.

The exons in the amylose gene from each variety have been sequenced but the data has not yet been correlated with amylose structure data.

Progress has been made in determining a way to measure the number of amylose molecules in a sample. This technique is difficult and progress has been slow, but has been successful with the smaller chains of amylopectin.

Investigation of the molecular mechanisms of starch quality (3403)

Project Leader:
Dr Christopher Blanchard
Charles Sturt University
Wagga Wagga

Objectives

The aim of this project is to characterise known rice genes and isolate new rice gene promoters that may be important for rice quality. A component of this project is the postgraduate project of Mr Andrew Eamens. He has completed part of his study at Charles Sturt University, Wagga Wagga and relocated to Canberra to carry out additional components on functional genomics.

Progress

The focus of this project over the past year has been to compare different methods for identifying genes and regulatory sequences in the rice genome. The methods used involve randomly inserting a "tag" into the genome that will either interrupt a gene or identify the expression pattern of a regulatory sequence.

The effectiveness of current functional genomics methods have been assessed and new techniques are being trialed. A number of new genes and regulatory sequence have been isolated and are being characterised. Isolation and characterisation of these sequences will provide a better understanding of the rice plant as well as providing tools for improving rice plants in the future.

Mr Eamens received a travel grant from the RACI Cereal Chemistry Division and presented his research at the 11th ICC International Cereal and Bread Congress.

Outcomes

* Improvement of gene tagging methodologies.

* Identification of genes responsible for various phenotypes.

* Identification of promoters specific for various tissue type.

Investigation of genetic diversity in rice cultivars (Honours) (5504)

Project Leader:
Dr Chris Blanchard
Charles Sturt University
Wagga Wagga

Soluble starch synthase I (SSSI) is responsible for the synthesis of the amylopectin fraction of starch. In most starch producing plants, a number of different forms of this enzyme have been identified, however, only one form of rice SSSI has been identified.

Objectives

The aim of this project is to screen a large number of rice varieties with different genetic backgrounds to determine if more than one form of the rice SSSI exists.

Progress

A comparison of rice soluble starch synthase I genes has been completed. The varieties studied appeared to have DNA sequences that were different to published sequences. A DNA sequence was identified that may form part of a newly identified gene which may have a function in starch synthesis.

Ms Sandra Oliver (Honours student) received a travel grant from the RACI Cereal Chemistry Division and presented her research at the 11th ICC International Cereal and Bread Congress.

Ms Oliver completed her honours thesis and received a grade of first class honours. She received high distinctions for all subjects attempted in her honours year, completing a perfect score of high distinctions for all subjects completed in her undergraduate degree. Ms Oliver was awarded a university medal for her outstanding efforts.

Outcomes

* Survey of rice SSSI genes completed.

* Presentation of research findings at a conference.

* Honours thesis completed.

MILESTONES

	Milestone	Year 1	Year 2	Year 3	Year 4 - 2000/2001	Yr 5	Yr 6	Yr 7
3.1	**Improved yield efficiency**							
	Appointment of assistant	X Deferred	Deferred					
	Introduction of male sterile lines	X 4	X 4	X 4				
	Evaluation of hybrid lines		X Commenced	X No lines developed	X Lines not developed			
	Evaluation of tropical japonica lines	X 4	X 4	X Discontinued				
	Development and evaluation of inducible male sterility		X RIRDC project	X RIRDC project				
	Evaluation of available apomictic systems		X RIRDC project	X RIRDC project	X RIRDC project	X	X	X
	Incorporation of improved yield traits		X Commenced	X 4	X 4	X	X	X
3.2	**Stress tolerance**							
	Cold scientist appointed - develop assay methods for pollen sterility - ABA assay - potential genes isolated - insert and test useful constructs - student project commenced - genes incorporated from *Zinania*	X 4 X 4 X Developed X 4 X 4	 X 4 X Commenced X 4 X RIRDC project	 X 4 X 4 X RIRDC project	 X 4 X 4			
	Bloodworm resistance - feasibility investigated - insertion of genes	X Commenced	X Partially achieved (see report for 3.2)	X 4 X 4	 X 4	 X		
	Allelopathy - student appointed - varieties introduced - mechanics studied - characters incorporated	X Deferred X Commenced X Deferred	4 X Partially achieved X Deferred	X 4	X 4 X Characters not available yet	X	X	X
	Salt tolerance - commercial varieties evaluated - resistance incorporated	X 4	X 4 X Commenced	X Continuing	X 4	X	X	X
3.3	**Breeding methods**							
	Isolated microspore culture - conditions optimised - optimise response - evaluate cultivar response - doubled haploid production - extension of technique	X Partially achieved X Partially achieved	X Commenced X Commenced X Not achieved	X 4 X 4 X Commenced	X 4 X 4	X X	X X	X X
	Development of markers for semi-dwarf and fragrance		X RIRDC project	X RIRDC project	X RIRDC project			
	Extension of markers to other traits			cold		X	X	X
	Development of male sterility				X RIRDC project	X	X	X
3.4	**Breeding for quality attributes**							
	Appointment of research officer, PhD student		X 4					
	Appointment of a technical officer		X 4					

	Milestone	Year 1	Year 2	Year 3	Year 4 - 2000/2001	Yr 5	Yr 6	Yr 7
	Evaluate factors promoting chalkiness	Promoted from Year 2 to Year 1	X transferred to RIRDC project	X RIRDC project	X RIRDC project			
	Evaluate factors promoting suncracking	X Waxy gene	X Commenced	X 4	X 4			
	Evaluate novel quality characteristics		X Commenced	X 4	X 4	X	X	X

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

4= Achieved (if not achieved, status provided.)

See Part C