COOPERATIVE RESEARCH CENTRE
FOR SUSTAINABLE RICE PRODUCTION

ANNUAL REPORT 1998/1999

Established and supported under the
Australian Government’s Cooperative Research Centres Program
COOPERATIVE RESEARCH CENTRE FOR SUSTAINABLE RICE PRODUCTION

ANNUAL REPORT
1998/1999

An unincorporated joint venture between:

Charles Sturt University
The University of Sydney
Ricegrowers’ Co-operative Limited
CSIRO
(Plant Industry, Land and Water and Entomology)
NSW Agriculture
NSW Department of Land and Water Conservation
Rural Industries Research and Development Corporation

Established and supported under the Australian Government’s Cooperative Research Centres Program
**CENTRE OBJECTIVES**

**MISSION**

The Cooperative Research Centre for Sustainable Rice Production will increase the economic, environmental and social sustainability of the Australian rice industry and enhance its international competitiveness through both strategic and tactical research and implementation of practical, cost-effective programs.

**OBJECTIVES**

This CRC aims to increase the contribution the rice industry makes to the national economy and to the welfare of all Australians by:

- generating knowledge to improve the sustainability of the natural resources and the systems used to produce rice;
- developing germplasm which will be the basis of a sustainable increase in rice yields and quality;
- developing a more strategic base for rice research in Australia; and
- formally linking key agencies involved in rice research, education and extension and focusing their effort on a common purpose.

ISSN 1444-643X
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXECUTIVE SUMMARY, HIGHLIGHTS</td>
<td>1</td>
</tr>
<tr>
<td>Chairman’s Report</td>
<td>1</td>
</tr>
<tr>
<td>Director’s Report</td>
<td>3</td>
</tr>
<tr>
<td>DESCRIPTION OF STRUCTURE AND MANAGEMENT</td>
<td>6</td>
</tr>
<tr>
<td>COOPERATIVE LINKAGES</td>
<td>11</td>
</tr>
<tr>
<td>RESEARCH</td>
<td>17</td>
</tr>
<tr>
<td>Sustainability of Natural Resources</td>
<td>17</td>
</tr>
<tr>
<td>Sustainable Production Systems</td>
<td>36</td>
</tr>
<tr>
<td>Genetic Improvement for Sustainable Production</td>
<td>53</td>
</tr>
<tr>
<td>Product and Process Development</td>
<td>65</td>
</tr>
<tr>
<td>EDUCATION AND TRAINING</td>
<td>73</td>
</tr>
<tr>
<td>Education, Skills Development and Technology Transfer</td>
<td>73</td>
</tr>
<tr>
<td>UTILISATION AND APPLICATION OF THE RESEARCH, COMMERCIALISATION, LINKS</td>
<td>83</td>
</tr>
<tr>
<td>WITH USERS</td>
<td></td>
</tr>
<tr>
<td>STAFFING AND ADMINISTRATION</td>
<td>86</td>
</tr>
<tr>
<td>LIST OF PUBLICATIONS AND PATENTS</td>
<td>98</td>
</tr>
<tr>
<td>PUBLIC PRESENTATIONS, PUBLIC RELATIONS &amp; COMMUNICATION</td>
<td>101</td>
</tr>
<tr>
<td>AWARDS</td>
<td>109</td>
</tr>
<tr>
<td>PERFORMANCE INDICATORS</td>
<td>110</td>
</tr>
<tr>
<td>BUDGET</td>
<td>114</td>
</tr>
<tr>
<td>AUDIT</td>
<td>121</td>
</tr>
<tr>
<td>GLOSSARY</td>
<td>123</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

Chairman’s Report

Mr Ian Davidge AO
Chairman, Rice
CRC

Achievements

As we approach the formal second year review of the CRC, which is the most important milestone of our activities so far, we can reflect on substantial and satisfying progress.

The objective of integrating different organisations and the amalgamation of the various research talents which are richly spread throughout a wide range of activities has been remarkably effective. This is particularly evident in the quality of supervision by senior researchers and the enthusiastic response from the highly motivated and serious postgraduate students.

For the first time there has been a coherent and formalised marshalling of the extensive individual resources of talent within the universities, CSIRO, RIRDC, Departments of Agriculture and Land and Water Resources, the rice processing industry and, of course, the base clientele of rice farmers. This accumulation of scientific knowledge is going to prove vital to the primary objective of maintaining rice production, indispensable as a base of irrigation farming in NSW.

It weighs heavily on the CRC to provide stewardship of scientific resources to ensure that every aspect of rice production receives the greatest support and attention to maintain the vitality and progress of this pivotally important industry.

Superimposed is the profoundly significant fact of the skilful use of the annually renewing resource of irrigation water. The integration of the wide research resources of the CRC to give a sound and tested scientific base for this management is of critical importance. The issues surrounding water resource utilisation range far beyond the science of irrigation and the rice industry must always ensure that its role in the total water debate is fully understood and protected. It is equally important that the pursuit of excellence in rice production is always mindful of environmental and regional responsibilities. There is clear evidence that the compatibility of rice with the total structural health of soil and water can be maintained, as predicted in our proposal for funding for the CRC.
The CRC has accrued notable advances in production-related areas, including a new approach to predicting soil nitrogen availability, identification of plant characteristics that will improve cold tolerance and the role that varietal selection can play in enhancing nutritional aspects of rice, including improved mineral availability in the diet.

There can be no rice industry if the production of rice is not truly commercial.

Export remains the key to commercial success and because Australia is alone in the world in having a virtually unsubsidised rice industry, coupled with a policy of free and untariffed imports, production efficiency at all levels and particularly on farm, is crucial. In the maintenance of commercial superiority, fundamental quality aspects must be maintained and the progress we are making in starch chemistry, whole grain production and better processing are significantly underpinning our developed position of a supplier of quality rice.

It is quite exciting to see the potential within our participators in the Rice CRC. The enthusiasm of the developing scientists and the pride they create amongst their colleagues and supervisors is clearly evident. This skills base will form a resource for agricultural and land science for years to come. The growing system of interdependence which is characterising this CRC is a tribute to our participators. I must thank them and their organisations for the support they are giving to us and the genuine desire they demonstrate to make this CRC singularly effective.

It appears that all CRC’s encounter considerable difficulties in the initial establishment period. This is behind us and we are now emerging into a mature phase where our structure is in place and our work proceeding effectively. This has been achieved by the perseverance and hard work of our Director, Dr Laurie Lewin. His courteous and considerate attitude to everyone involved has been a great tool in creating the harmonious nature of our CRC.

Mr Gordon Hart, in his position of Executive Officer, has been able to link together the complex financial and accounting procedures which are uniquely part of a CRC. His development of the special systems has been most effective.

We have been fortunate to have the talents of Ms Julie Symes as our Executive Secretary. Julie has a great grasp on the day-to-day operations and has quickly become an indispensable part of our Centre.

The support of the Secretariat in Canberra is appreciated and, with its help, we look forward to the challenges of the future with confidence.

Ian Davidge
Chairman
**Director's Report**

Dr Laurie Lewin, Director, Rice CRC

This report marks the completion of the second year of the Cooperative Research Centre for Sustainable Rice Production. It was a year of building during which the program was consolidated. Most pleasing was the establishment of strong links and the building of a culture. Rice CRC functions such as the first symposium and the induction tour were very constructive. I was impressed by the harmony and strength of purpose displayed by the participants. This was an excellent example of the synergy that can be generated when different groups, with a diversity of interests and experience, are able to work together.

The year provided an opportunity to reassess the program and to make minor modifications. On the whole, however, the original plan remains intact and there is real opportunity to make a difference to the industry.

**The rice industry in 1998/99**

The rice season commenced with a warning on its vulnerability to water supply. There were historically low dam levels and the prospect of area restrictions. Late spring rain, however, altered the prospects dramatically and plantings at 150,000 hectares were more than the previous year.

The season was a warm one. There were few periods of low temperature during the reproductive period and an absence of traditional cold damage. Yields were high and the second highest average yield of 9.2 t/ha was recorded. Production was a record. Grain quality was generally improved over the last two seasons. From a production view, therefore, the season was a pleasing one. Prices had fallen, however, by up to $20 per tonne. By the season conclusion, dams were again at low levels, thus raising the prospect of a difficult 1999/2000 season.

The industry is vulnerable to water supply. Current issues such as the cap on diversions, contributions to environmental flows and to eastern-flowing river systems all have potential to influence water allocated to rice. Important advances in water use efficiency have been made through better definition of soils and improved efficiency of distribution. We must continue to make progress in this area and the workshop held during the year on water use efficiency was an important further step in this direction.

The Rice CRC must continue to emphasise the need for improved efficiency of water use. This may be achieved through improved productivity, reduced duration of ponding and reduced water application. We are addressing all of these.
With a series of relatively dry winters, there is evidence of falling watertables. Apportioning the contribution of climate and management is not easy but both have probably contributed. Research is planned to determine this. Undoubtedly, however, we must continue to emphasise the importance of the impact of rice production on watertables.

Other areas of environmental concern have been addressed through understanding attitudes and the development of community-based Land and Water Management Plans. The role of this CRC is to provide objective information in key areas to further enhance this process.

Rice productivity is continuing to improve. This brings attendant problems such as impact on fertility and potential problems due to changing rotation systems. It is significant that these are being addressed in the Programs of the Rice CRC.

There is real potential in the development of a nitrogen soil test for rice. Nitrogen application rate remains one of the more difficult decisions facing rice growers. Under or over application can dramatically impact on both productivity and profit.

Cold was not a general problem in 1998/99. However it is still one of the most important unresolved problems facing the industry. Water supply and cold account for the major uncertainties associated with rice production. Significant progress in Programs 2 and 3 has been made in understanding the cold problem at many plant levels and in identifying cultivars with improved resistance to cold.

Improved yield potential and reduced duration are essential for both improved water use efficiency and greater competitiveness. There are many genetic sources for reduced duration but combining these with more efficient productivity is an important problem. New introductions from Eastern Europe are helping to address this problem.

New methods are being developed to improve the efficiency of breeding. Anther and microspore culture and a better understanding of the genetic control of cold tolerance will all improve the competitiveness of the rice industry over the longer term.

The Australian rice industry must compete on the basis of grain quality. Suncracking has always been a major problem for the industry as it is influenced by the dry climatic conditions during grain ripening. Initial work showing the importance of proteins in suncracking is of major importance. Studies on the factors controlling starch structure under both genetic and environmental control will be important in future developments of rice varieties.

Australian rice is generally sold as a processed product and, where possible, in quality conscious markets. The industry must meet the highest standards of quality and this demands understanding the aeration, storage, processing, packaging, shipping and marketing components of the industry.

Rice CRC Programs have identified those components of the processing sector most likely to limit long-term sustainability and most likely to provide improved productivity. Improvements in processing control and the start of the research to provide more sustainable post-milling pest control practices are early examples of the success of Program 4. Some rice is sold with additives. The success of a project to add folate to the rice is already paying dividends. Quality assurance will be an important component of all food businesses in future. The Rice CRC is assisting the introduction of the process into the processing sector.
The introduction of education projects has been of major significance in the early life of the Rice CRC. New rice specific vocational training courses are under development, as are courses aimed at undergraduate students. It has been particularly pleasing, however, to watch the development of postgraduate training opportunities. Prior to the establishment of the Rice CRC, few postgraduate scholarships were available for studies aimed specifically at the Australian rice industry. The Rice CRC has provided significant opportunity for studies in all areas of rice production, processing and education. The potential of these scholars to contribute to the longer term future of the rice industry will be of great significance in underpinning its future.

**New initiatives**

The Rice CRC will soon appoint a full time Communications Officer. This will facilitate contacts within the organisation and also with the general public. This position will be supported by another position with the Murrumbidgee College of Agriculture to develop materials and facilities to publicise the achievements of rice research and development for the industry to the general public, school students and overseas visitors. These positions will raise the profile of the Rice CRC and highlight the importance of rice research and development for the rice industry.

The operational procedures of the Rice CRC have evolved over its life. The Board has ensured that the overall operating strategies have been developed. They have shown a willingness to see the Programs of the Rice CRC develop to the benefit of the industry and not over-emphasise the importance of the individual components. I am indebted to the contribution of the individual Board members who have shown great skill in the establishment phase.

Mr Ian Davidge, as Chairman, has particularly contributed much to the formative years of the CRC. We were all gratified to learn of his AO Award in the Queen’s Birthday Honours List for services to the rice industry. There surely could be no more worthy recipient.

The Committee is made up of Program Leaders and other key representatives. They have combined to ensure the smooth working of the organisation and in continuing to promote cooperation and purpose in the Programs. I am particularly indebted to Program Leaders who have worked hard, often with little reward, to ensure the development of their Programs. Their dedication has been important to the Rice CRC.

The administration team of Mr Gordon Hart and Ms Julie Symes have had a very difficult task in creating and maintaining the accounting and office structures. Mrs Jan Hubatka was instrumental in establishing office procedures for the organisation. Her support was certainly important and we are pleased she will be returning to help on specific occasions.

It is the totality of contributions to the Rice CRC that are important. The combined dedication, skill and talent is impressive. I know they are the factors that will ensure the sustainability and success of the Australian rice industry.

*Laurie Lewin,*
*Director*
DESCRIPTION OF STRUCTURE AND MANAGEMENT

The Cooperative Research Centre for Sustainable Rice Production is an unincorporated joint venture established in 1997 by an Agreement between the Centre parties.

Charles Sturt University
The University of Sydney
CSIRO
NSW Agriculture
NSW Department of Land and Water Conservation
Rural Industries Research and Development Corporation
Ricegrowers’ Co-operative Limited

and an Agreement with the Commonwealth of Australia.

The organisational structure of the Centre is outlined below. The management structure consists of the Board and the Director. The Board and Director are advised by Committees and supported by an administration office dealing with administrative and financial activities. The Board is responsible for the strategic direction of the Centre and for ensuring Centre management. The Director is responsible for day-to-day operations of the Rice CRC. He is assisted by a Management Committee which includes key staff and Program Leaders. The Rice Research and Development Committee of RIRDC is an advisory committee to the Rice CRC. The Centre Agent is NSW Agriculture and it provides financial and research program/project service and support for the Centre. The Centre’s administrative office is located at the Yanco Agricultural Institute (NSW Agriculture).
THE BOARD

The Centre is governed by a Board of Directors comprising an independent chairperson, a high level nominee of each of the participating core partners and two persons to represent the interests of the Centre Associates and the Riverina community.

The Board meets a minimum of four times a year, usually two weeks after a Committee meeting so any issues requiring consent of the Board can be dealt with promptly.

The Board has the following functions and powers.

1. To establish policies for the Centre which cover research, education, training, intellectual property, commercialisation, planning, staffing, finance, accounting, reporting and such other matters as the Board considers necessary for the conduct of the business of the Centre, and its accountability to the Commonwealth and the participants pursuant to the Commonwealth and Centre Agreements.

2. To approve the activities of the Centre annually and the subsequent Annual Budget as described in Schedules 1 and 4 of the Commonwealth Agreement.

3. To monitor, measure and approve the performance indicators for the Centre.

4. To appoint, oversee and review the performance of the Director.

5. To take account of the relevant policies of each of the parties when considering any matter.

6. To authorise others to act on behalf of the Board and of the Centre.

7. To review the parties' contributions and seek to amend the Schedules of the Commonwealth Agreement provided that affected parties shall have agreed to any change in or any change to their intellectual property arrangements. Such changes will require the approval of the Commonwealth.

8. To consider and, if appropriate, approve new Programs recommended by the Management Committee. Such new Programs will also require approval by the Commonwealth and appropriate changes to the Schedules of the Commonwealth Agreement.

Board membership for 1998/99:

Mr Ian Davidge  
Chair

Dr Laurie Lewin  
Director, Rice CRC

Prof. Kath Bowmer  
Charles Sturt University

Alternative:
Prof. Jim Pratley  
Charles Sturt University

Prof. Don Napper  
*Alternative:* Prof. Don Marshall  
The University of Sydney

Dr Graham Harris  
*Alternative:* Dr Jim Peacock  
CSIRO Land and Water

Ms Helen Scott-Orr  
*Alternative:* Mr Martin May  
NSW Agriculture

Mr Geoff Fishburn  
[replaced Mr David Mittelheuser]  
NSW Department of Land and Water Conservation

Mr Jim Kennedy  
[to December 1998]  
Ricegrowers’ Co-operative Ltd

Mr Richard Day  
[from December 1998]  
*Alternative:* Dr Keith Hutton  
[from December 1998]  
Ricegrowers’ Co-operative Ltd

Mr Jim Kennedy  
[from December 1998]  
Prime Minister’s Supermarket to Asia Council

Mr John Herbert  
Rural Industries Research and Development Corporation (RIRDC)  
*Alternative:* Mr Peter Core  
Rural Industries Research and Development Corporation

Mr Peter Draper  
Rice Research and Development Committee (RRDC)

**MANAGEMENT COMMITTEE**

The Management Committee comprises the Director, the Program Leaders, the Executive Officer and representatives of the parties, not otherwise represented.

The Management Committee assists the Director in attaining the objectives of the Centre through the implementation of the policies of the Board in relation to research, education and training, technology transfer, publication of research outcomes, finance and staffing.

The Committee coordinates the Centre’s activities and prepares new programs and policies for consideration by the Board.
The Committee meets a minimum of four times a year, usually two weeks before the next Board meeting so that any issues requiring consent of the Board can be dealt with promptly.

**Management Committee membership for 1998/99:**

Dr Laurie Lewin
Chairman

Mr Gordon Hart
Executive Officer, Rice CRC

Mr John Blackwell
CSIRO Land and Water [Program 1 Leader]

Dr Liz Dennis
CSIRO Plant Industry [Program 3 Leader]

Mr Graeme Marteene
Ricegrowers’ Co-operative Ltd [Program 4 Leader]
[replaced Mr Jim Kennedy]

Mr Peter Cregan
Charles Sturt University [Program 5 Leader]
[to 9 June 1999]

Dr Phillip Eberbach
Charles Sturt University [Program 5 Leader]
[from 9 June 1999]

Dr Bruce Sutton
The University of Sydney

Mr Ary Van der Lely
NSW Department of Land and Water Conservation

Dr Jeff Davis
Rural Industries Research and Development Corporation

Dr Graeme Batten
NSW Agriculture [Program 2 Leader]

Mr Ian Davidge
Chairman, Rice CRC Board

**ADVISORY COMMITTEE**

The Advisory Committee function to the Centre is undertaken by the Rice Research and Development Committee (RRDC) of the Rural Industries Research and Development Corporation (RIRDC).

As the Advisory Committee to the Centre, the RIRDC Rice Research and Development Committee assists in providing broader input to the policies, planning and Programs of the Centre and to ensure coordination of research projects and functions.

The Director maintains frequent direct contact with members of the Committee to advise on the activities of the Centre and seek advice and comment in return.

Members of the Committee also receive invitations to the Rice CRC annual Symposium, workshops conducted by the Centre and to provide advice to the Board on appropriate matters.
CENTRE VISITOR

The Rice CRC’s Visitor is Mr Jim Miller. He is appointed by the CRC Secretariat to liaise with and assist in monitoring the CRC’s he has been allocated. He acts as an independent adviser and helps establish constructive links between the Secretariat and the CRC’s.

CENTRE PROGRAMS

The research Programs are broken into five main areas, these are :-

1. Sustainability of Natural Resources in Rice-Based Cropping Systems.
2. Sustainable Production Systems.
3. Genetic Improvement for Sustainable Production.
5. Education, Skills Development and Technology Transfer.

Each Program has a leader to direct and monitor the research activities. The Programs are further divided into Sub-Programs which also have a nominated leader. Beneath each Sub-Program are the research projects which all have a Project Leader who is the principal researcher.

GENERAL

Management’s approach to supporting cooperation and commitment of staff is enhanced through the inclusion of high level executive/management staff from each participating organisation on the Board, together with Program Leaders and representatives of parties not otherwise represented on the Management Committee. This structure provides a management resource to ensure our objectives toward cooperation and staff commitment issues are adequately dealt with and properly facilitated.

To encourage commitment and a sense of belonging by staff, the Rice CRC holds an annual symposium, with the first Symposium held in August 1998 at Yanco Agricultural Institute. All participating staff, administrators, advisory members and students are invited to attend. Each Program is provided with the opportunity to present developments of its research. The second Symposium is planned for August 1999 at Yanco.

Development of the Centre culture is an ongoing objective and we encourage participants to put aside the interests of their organisations so that they feel a sense of ownership and an obligation towards the Rice CRC. To achieve and assist in this aim we have an independent Chairman in Ian Davidge; we have set up our administrative office to clearly identify our independence from our host; we have established an individual identity for communications; we produce a quarterly newsletter which is distributed to all people involved in our CRC; and we hold an annual Symposium. The Symposium provides the opportunity to bring together all involved to encourage and facilitate a shared basis of research activity.
COOPERATIVE LINKAGES

The Rice CRC is a relatively new organisation that sits within an existing network of research, development and service structures impacting on rice production and resource use in the southern irrigation areas. These groups include research, extension and education service providers, regulatory authorities, irrigation suppliers, community groups such as Land and Water Management Plan groups and industry organisations. There have also been active links with international organisations at various levels.

The role of the Rice CRC is to establish new links or to enhance those that have not been strong in the past.

Strong links are important to ensure cooperation across all levels from natural resource use to marketing of end-product. The Rice CRC does not operate in isolation from either more applied research and development activities or the day-to-day operations of the industry. It is linked to the existing community and industry infrastructure in a way that aims to ensure a seamless two way exchange between the theoretical and the practical application of technology (Fig. 1).

Cooperative links have been fostered internally, with outside organisations within Australia and internationally.

Figure 1
Many of the partners in the Rice CRC had not worked closely together prior to its formation. Establishing links between these participants has been an important task in the initial phase.

**Rice CRC Symposium**

The first general symposium of the Rice CRC was held in August 1998. This provided an ideal opportunity for all participants to interact, to share the total program and to form a Rice CRC culture. The Symposium was important in an organisation such as the Rice CRC whose participants are geographically distributed both within and between Programs. There was also an opportunity for Program group meetings as part of the Symposium. Groups to avail themselves of this opportunity were Program 1, Sub-Program 2.1, the cold interest group (Sub-Programs 2.2 and 3.2) and postgraduate students. The format of the Symposium was successful in generating a spirit of cooperation and a greater understanding of the scope of the work.

**Program Meetings**

Additional Program meetings were held for Program 1; the cold focus group from Programs 2 and 3; the nutrition group (Sub-Program 2.1); components of Program 4 and Program 5. There have been many informal discussions on joint projects.

Few of the research projects within the Rice CRC operated in isolation from other research groups. Even where the project investigators are from a single organisation, the work is generally linked to other projects from other organisations. This has generated significant cooperation within the organisation.

**Induction Tour**

In November 1998 the Chairman and Director of the Rice CRC convened and hosted a two-day “Rice Induction Tour” which was aimed at broadening participants’ knowledge of the rice industry, from paddock to plate, and also providing an update on the status of some of the Rice CRC projects. Features of the tour were visits to rice farms where participants were able to interact with rice producers as well as inspect growing rice crops, inspections of field trials being carried out by participants of the Rice CRC and inspection of storage and processing facilities. One of the major benefits of the tour was the opportunity for all tour participants, and particularly PhD students, who may not otherwise have met, to establish networks with a view to forming future cooperative linkages. The feedback from participants was very positive and it is anticipated that a similar exercise will be conducted on a yearly basis.
Newsletters

Rice CRC members are invited to contribute to our internal newsletter, which is distributed to all participants. Two newsletters were distributed in the last financial year. The Rice CRC will be appointing a Communications Officer in the near future and it is intended to increase the number of newsletters produced each year, as well as increase the level of communication to participants generally.

Staff have also submitted articles to newsletters outside of the CRC, with two examples being:-


LINKS WITH OTHER ORGANISATIONS

The Rice CRC has not been isolated from other organisations with an interest in rice research, technology transfer or education. Links have been maintained with other research programs funded through RIRDC. This has been fostered at Board and Management Committee level where RIRDC and the Rice Research and Development Committee are represented.

Participants in the Rice CRC have actively sought opportunities with organisations that are not part of the core structure. Some of these have been through postgraduate studentships while others have been through mutual research interest. These additional links have included participants from:-

- Australian National University: cold tolerance
- University of Queensland: cold tolerance
- University of New South Wales: rice quality; regional salinity prediction modelling
- University of Wollongong: rice quality
- University of Technology, Sydney: groundwater and salinity dynamics
- Southern Cross University: rice biotechnology

INTERNATIONAL LINKS

There have always been some links with rice research workers internationally. These have been particularly strong with those from temperate rice producing countries such as the United States of America. Links have also been maintained with the International Rice Research Institute (IRRI) but opportunities for cooperative research with IRRI have been restricted by the difference in climatic conditions.

Participants in the Rice CRC have sought improved links with other locations. Japanese research, in particular, has much to offer and these links have been particularly strengthened.
Specific initiatives in 1998/99 have included extended visits from international scientists, visits to international locations and links to international projects through Australian Centre for International Agricultural Research (ACIAR) funded research.

**International Projects**

Program 1205 “Quantifying and maximising the benefits of crops after rice” has a relationship with ACIAR funded Project 9432 “Nutrient and irrigation management for sustainable rice-wheat cropping systems in Bangladesh and Australia”. The partners in the project are The University of Melbourne, Bangladesh Rice Research Institute and the Bangladesh Agricultural Research Institute. This project will be reviewed in February 2000 and the possibility of a new or extended project will be determined. There is a possibility for the direct inclusion of a field project in Australia which would provide training opportunities for Bangladeshi staff in the determination of crop water balance and soil hydrology. We will be seeking opportunities related to watertable and salinity management.

Links have been maintained with ACIAR Project 95/100 “Plant breeding strategies for rainfed lowland rice in north-east Thailand and Laos”. This project is managed by Assoc Prof Shu Fukai, University of Queensland. The involvement of the Rice CRC was through studies on genotype-by-environment interactions for phenology (ACIAR Sub-Program 5) and particularly focused on cold-by-nitrogen interactions.

**Visiting Scientists**

Mr Yukihiro Hamada, Aichi Agricultural Research Centre, Japan spent six months with Dr Graeme Batten at Yanco Agricultural Institute. Mr Hamada worked on comparisons between different sowing methods and slow release nitrogen application.

Dr Ryoji Sameshima, Tohoku National Agricultural Experiment Station, Morioka, Japan spent six weeks with Mr Rob Williams. Dr Sameshima modelled cold effects on commercial rice yield.

Dr Deep (HS) Saini, University of Montreal, Canada, spent a sabbatical period with Dr Liz Dennis at CSIRO Plant Industry in Canberra. Dr Saini provided support with anther sampling and identification of development stages. He was also a contributor to the studies on the molecular basis of cold tolerance. Dr Saini attended the Cold Workshop in January 1999.

**Overseas Visits By CRC Staff**

John Madden (CSIRO Land and Water) spent two weeks at the International Water Management Institute in Pakistan in March 1999 to explain the SWAGMAN Farm Model and to explore potential application in Japan.

Dr Laurie Lewin visited the Dale Bumper National Rice Research Centre, Stuttgart, Arkansas to discuss potential cooperation with the Director, Dr Neil Rutger and staff at the Centre. The conference associated with this visit provided an opportunity for discussion with key international scientists from IRRI, Egypt, South America and other States of the USA.
Dr Liz Humphreys (CSIRO Land and Water) visited ACIAR project rice-wheat experiments in Bangladesh in October 1998 and April 1999. Dr Humphreys and Mr David Smith also made presentations at the mid–project review in Bangladesh in October 1998.

The 2nd Temperate Rice Conference in Sacramento, California held in June 1999 provided a significant opportunity to meet with international scientists and visit key research locations in the USA. Those to capitalise on this opportunity included Dr Craig Russell, Dr Rudy Dolferus, Dr Stuart Helliwell, Dr Norman Darvey, Dr Laurie Lewin, Dr Melissa Fitzgerald and Dr John Angus.

The following table identifies linkages established within Rice CRC projects.

<table>
<thead>
<tr>
<th>Project No.</th>
<th>Chief Investigators</th>
<th>Linkages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1102</td>
<td>NSW Agriculture</td>
<td>Murray Irrigation Limited, Coleambally Irrigation Corporation, Jemalong Irrigation Limited</td>
</tr>
<tr>
<td>1104</td>
<td>NSW Agriculture</td>
<td>Coleambally Irrigation Corporation</td>
</tr>
<tr>
<td>1105</td>
<td>CSIRO Land and Water</td>
<td>NSW Agriculture</td>
</tr>
<tr>
<td>1201</td>
<td>CSIRO Land and Water</td>
<td>Coleambally Irrigation Corporation, Murrumbidgee Irrigation Limited, Murray Irrigation Limited, Irrigation Research and Extension Committee</td>
</tr>
<tr>
<td>1202</td>
<td>Dept. of Land &amp; Water Conservation</td>
<td></td>
</tr>
<tr>
<td>1203</td>
<td>Dept. of Land &amp; Water Conservation</td>
<td>Murrumbidgee Irrigation Limited, Prof Gates (Colorado)</td>
</tr>
<tr>
<td>1204</td>
<td>NSW Agriculture</td>
<td></td>
</tr>
<tr>
<td>1205</td>
<td>CSIRO Land and Water</td>
<td>Private consultant, ACIAR Project 9432</td>
</tr>
<tr>
<td>1206</td>
<td>CSIRO Land and Water/Private consultant</td>
<td>ACIAR Project 9432</td>
</tr>
<tr>
<td>1301/1302</td>
<td>CSIRO Land and Water</td>
<td>Projects in development</td>
</tr>
<tr>
<td>1303</td>
<td>CSIRO Entomology</td>
<td></td>
</tr>
<tr>
<td>1401(a)</td>
<td>Dept. of Land &amp; Water Conservation, University of New South Wales</td>
<td></td>
</tr>
<tr>
<td>1401(b)</td>
<td>Dept. of Land &amp; Water Conservation, University of Technology Sydney</td>
<td>CSIRO Land and Water, NSW Agriculture</td>
</tr>
<tr>
<td>1403</td>
<td>CSIRO Land and Water</td>
<td>Project in development</td>
</tr>
<tr>
<td>2101</td>
<td>Charles Sturt University</td>
<td>CSIRO, NSW Agriculture, Incitec, University of New England</td>
</tr>
<tr>
<td>2102</td>
<td>Charles Sturt University</td>
<td>NSW Agriculture</td>
</tr>
<tr>
<td>2103</td>
<td>NSW Agriculture</td>
<td>Charles Sturt University</td>
</tr>
<tr>
<td>2105</td>
<td>NSW Agriculture</td>
<td></td>
</tr>
<tr>
<td>2201</td>
<td>NSW Agriculture</td>
<td>University of Queensland, linked to cold group</td>
</tr>
<tr>
<td>2203</td>
<td>The University of Sydney</td>
<td>Linked to cold group</td>
</tr>
<tr>
<td>2204</td>
<td>The University of Sydney</td>
<td>Linked to cold group</td>
</tr>
<tr>
<td>2205</td>
<td>University of Queensland</td>
<td>NSW Agriculture, linked to cold group</td>
</tr>
<tr>
<td>2301</td>
<td>NSW Agriculture/The University of Sydney</td>
<td></td>
</tr>
<tr>
<td>2302</td>
<td>NSW Agriculture</td>
<td>The University of Sydney, Adelaide University</td>
</tr>
<tr>
<td>2303</td>
<td>Ricegrowers’ Co-operative Limited</td>
<td>NSW Agriculture</td>
</tr>
<tr>
<td>2401</td>
<td>NSW Agriculture, Charles Sturt University</td>
<td></td>
</tr>
<tr>
<td>2402</td>
<td>NSW Agriculture, Charles Sturt University</td>
<td></td>
</tr>
<tr>
<td>2404</td>
<td>NSW Agriculture, Charles Sturt University</td>
<td>Charles Sturt University, CSIRO Entomology</td>
</tr>
<tr>
<td>2405</td>
<td>NSW Agriculture, University of Melbourne</td>
<td>Charles Sturt University</td>
</tr>
<tr>
<td>2406</td>
<td>NSW Agriculture/The University of Sydney</td>
<td></td>
</tr>
<tr>
<td>Project No.</td>
<td>Chief Investigators</td>
<td>Linkages</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------</td>
<td>----------</td>
</tr>
<tr>
<td>3101</td>
<td>NSW Agriculture</td>
<td></td>
</tr>
<tr>
<td>3102</td>
<td>CSIRO Plant Industry</td>
<td>NSW Agriculture, Australian National University RSBS, GRDC project, ACIAR project, Redpath Technical Services</td>
</tr>
<tr>
<td>3201/3204</td>
<td>CSIRO Plant Industry</td>
<td>Dr Deep Saini (Montreal), linked to cold group</td>
</tr>
<tr>
<td>3203</td>
<td>CSIRO Entomology, CSIRO Plant Industry</td>
<td>NSW Agriculture</td>
</tr>
<tr>
<td>3301</td>
<td>The University of Sydney</td>
<td>NSW Agriculture, IRRI, Hungary</td>
</tr>
<tr>
<td>3402</td>
<td>NSW Agriculture</td>
<td>Charles Sturt University</td>
</tr>
<tr>
<td>3403</td>
<td>Charles Sturt University</td>
<td>NSW Agriculture, CSIRO Plant Industry</td>
</tr>
<tr>
<td>4101</td>
<td>Ricegrowers’ Co-operative Limited</td>
<td></td>
</tr>
<tr>
<td>4201</td>
<td>Ricegrowers’ Co-operative Limited</td>
<td>CSIRO Stored Grains Research Laboratory</td>
</tr>
<tr>
<td>4301</td>
<td>Ricegrowers’ Co-operative Limited</td>
<td>University of New South Wales, Wollongong University</td>
</tr>
<tr>
<td>4401</td>
<td>Ricegrowers’ Co-operative Limited</td>
<td></td>
</tr>
<tr>
<td>4501</td>
<td>The University of Sydney/Ricegrowers’ Co-operative Limited</td>
<td>BRI Australia Limited</td>
</tr>
<tr>
<td>4502</td>
<td>Ricegrowers’ Co-operative Limited</td>
<td></td>
</tr>
<tr>
<td>4503</td>
<td>Ricegrowers’ Co-operative Limited</td>
<td></td>
</tr>
<tr>
<td>5101</td>
<td>NSW Agriculture</td>
<td></td>
</tr>
<tr>
<td>5201</td>
<td>Charles Sturt University</td>
<td>Coleambally Irrigation Corporation</td>
</tr>
<tr>
<td>5301</td>
<td>NSW Agriculture</td>
<td>Links to education</td>
</tr>
<tr>
<td>5401</td>
<td>Charles Sturt University</td>
<td>NSW Agriculture</td>
</tr>
</tbody>
</table>
RESEARCH

The research program is organised into five interrelated Programs which cover the general areas of natural resources, agronomy, genetic improvement, processing and education. Each Program has a new emphasis on those issues that impact on the future of the rice industry. All areas are important but Program 1 with its emphasis on natural resource use, and Program 5 with a renewed commitment to education at all levels, are central to the long term success of this CRC and the industry.

The Rice CRC program is largely new research. It has developed new relationships and stimulated focus on new and important issues. Early results are encouraging and exciting in some areas. It now seems assured that the program of research will contribute to the sustainability of the Australian rice industry.

PROGRAM 1

SUSTAINABILITY OF NATURAL RESOURCES

Program Leader:
Mr John Blackwell
CSIRO Land and Water
Griffith

The 1998/99 rice season was again a record rice season with 1.38 million tonnes of paddy produced in south-eastern Australia. Rice continues to be the major crop on the large area farms of the Murrumbidgee, Coleambally and Murray areas. This predominance of rice is for a good reason, farmers feel it is the only sure income available to them, with other crops seen as more speculative in nature. Nonetheless, rice should not be seen as a monoculture activity as each farm is a combination of other crops in a rice-based cropping system.

The rice industry remains the major user of irrigation water in southern Australia with 1800GL applied to the crop in 1998/99. Many other political, social, environmental and economic factors impact on the rice industry requiring it to address issues of sustainability with greater rigour.

Program 1 is making good progress toward the development of technologies to help irrigators and Land and Water Management Planners plan to use water more efficiently and with reduced impacts on ground and surface waters.

The scope of Program 1 has been greatly enhanced with two recent appointments – a Leader for Sub-Program 1.3 (surface drainage quality management) and a Project Leader for a major project developing tools to quantify the impact of management and climate on watertables and root zone salinity across the landscape.
Once projects in these two areas are operational, the Program will be demonstrably well focused to address major issues affecting the long-term sustainability of natural resources in rice-based cropping systems, specifically in the areas of:-

* improved land use capability assessment techniques to enable farm planning to minimise recharge from rice fields, irrigation channels and drains;
* techniques for identifying economic management options, at the farm and regional scales, that meet watertable and root zone salinity objectives;
* development of rice and rice-based cropping systems that reduce recharge and encourage discharge; and
* maintenance of surface drainage water quality.

1.1 Measurement and Mapping

Sub-Program Leader:
Mr Geoff Beecher
NSW Agriculture
Yanco

Better prediction of groundwater recharge from ricegrowing (1102)

Project Leader:
Mr Geoff Beecher
NSW Agriculture
Yanco

The aim of this project is to refine the rice land classification scheme, by including soil physico-chemical and landscape attributes, to enable more accurate prediction of the impacts of ponded rice culture on watertables.

Progress

Mr Neel Jinadasa has been investigating several methods for assessing soil sodicity in the field. These investigations were undertaken on soil samples from a range of depths 0-4 m and include comparison of the Emerson dispersion test, the Rengasamy jar turbidity test, the sodium absorption ratio (SAR) of saturation and 1:5 extracts, estimation of SAR from the concentration of sodium in the extract and its electrical conductivity, and evaluation of the pocket Horiba Cardy sodium meter for determining sodium in soil extracts.

Sodicity can be estimated from the turbidity of a 1:5 jar suspension using a modified Secchi disk. Generally, there is a good relationship between the disk reading and SAR in the 1:5 soil:water solution over a range of soil types and depths. However, soil texture and electrical conductivity are also required to classify saline-sodic soils.

Soils were selected from the four main soil types used for rice growing and samples to a depth of 4 m were used. Soil sodicity (SAR in the saturated paste) ranged from <1 to >30 and the samples included saline-sodic soils.
There was a good relationship between sodium concentration measured using the Cardy meter and using standard laboratory procedures (atomic absorption spectrometry) in the soil extract. There was also generally a good relationship between SAR in the 1:5 soil:water and saturation paste extracts and this relationship is being investigated further.

The Emerson dispersion test provides a measure of spontaneous dispersion of clay. Using the results of this test, a dispersion index was calculated and compared with soil sodicity SAR of the 1:5 soil:water solutions.

Determination of field scale variability in sodicity of the four major soil types is currently being undertaken. Soil sampling to 1.5 m has been completed at 60 sites over three soil types. The sites have been selected on the basis of EM31 values. Soil chemical properties including sodium levels are currently being assessed by a number of methods.

**Measurement of losses from on-farm channels and drains (1104)**

**Project Leader:**
Mr Saud Akbar  
NSW Agriculture  
Yanco

The aims of the project are to:

* determine the magnitude and importance of seepage losses from on-farm channels and drains in the Murrumbidgee Valley;
* develop farmer friendly methods for determining conveyance efficiency of on-farm channels and drains;
* identify the need for treatments to reduce losses from channels and drains; and
* use EM31 surveys to identify relationships between the seepage losses and EM values.

**Progress**

At this stage of the project a total of 283 seepage tests have been undertaken on six farms in the Murrumbidgee and Coleambally Irrigation Areas. The investigations covered a range of soil types from sands to clay loams.

The EM31 measurements provide a very good indication of the occurrence and amount of seepage. EM31 measures the effect of channel seepage rather than channel seepage itself, as EM31 response is related to soil salinity. The Idaho seepage meter provided useful results for seepage measurements. The combination of the Idaho seepage results and EM31 measurement provided a good technique for the identification and quantification of seepage from sections of the on-farm channels and drains.

This year more attention has been given to newly developed farm channels and drains - mostly one-to two-year-old channels are under observation. The results showed that most of the seepage took place where low EM31 readings were found. The seepage rates were generally much higher in the newly constructed channels or drains than in the older (15 to 30
years) channels and drains. The combination of weeds, sediment deposition and biologically induced pore clogging may cause the lower seepage in older channels and drains.

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 the physical and economic impacts of on-farm options to increase water use efficiency and provide a guide to the level of irrigation intensity and land use that will achieve natural resource and economic sustainability for individual farms;

* produce a validated model and methodology for estimating soil salinity trends from groundwater recharge and discharge factors;

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

* quantify the impact of growing wheat immediately after rice harvest on watertables and knowledge of farmer perceptions of such practices.

Optimising agronomic options at the farm scale (1201)

Project Leader:
Mr John Madden
CSIRO Land and Water
Griffith

The project aims to:-

* develop a model that will:-
  - assist in the evaluation of on-farm options to increase water use efficiency;
  - predict the effect of changing enterprise mix on rice area and water availability on irrigation farms;
  - provide benchmarks for water auditing at crop, farm and district levels;
  - identify irrigation intensity by land use options that will achieve natural resource and economic sustainability for individual farms; and
  - provide a better understanding of the trade-offs between environmental constraints and profitability;
* provide enhanced understanding of the important determinants of net recharge and optimal irrigation intensity; and

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

**Progress**

The current SWAGMAN Farm model was reviewed by two external consultants – one major error in the code was detected and this has been corrected. Several other improvements have been made in the model, including:-

* the development of a user-friendly interface;
* improved post-processor graphics;
* the capability of running the model in simulation or optimisation mode;
* the ability to set fixed minimum crop areas; and
* the use of more realistic starting soil water contents and an improved method for predicting the effect of recharge on watertable rise.

The model has also been enhanced to detect user-input errors that cause the optimisation solver to report “infeasible” solutions. These occur when the model equation system detects inconsistencies. Common errors include:-

* setting environmental constraints (such as minimum salinity changes or minimum allowable rise of the watertable) which cannot be achieved with nominated crop area constraints;
* inadvertently nominating a minimum crop area for a particular crop that is greater than the maximum area;
* setting minimum crop areas which require more water than the total allocation available to the farm.

An “infeasibility” form has been created that pops up and reports those encountered and suggests remedies.

A simulation model has been added to the optimisation model. The simulation model is in every respect similar to the optimisation model except that all constraints of the optimisation model have been removed. This enables the evaluation of the likely impact, on salinity and depth to the watertable, of an actual or envisaged farm condition. An additional input form is created to enable the user to specify farm areas by crop and soil. These were previously decision variables in the optimisation model.

The post-processor graphics were enhanced to include a breakdown of total farm net recharge into net recharge by crop. Future modifications may include net recharge by crop by soil type, and net change in root zone salinity by crop by soil type.

Calculation of watertable rise or fall has been improved. Drainable porosity is estimated as the difference between the porosity at saturation and at the initial soil water content. Previously it was assumed that the soil was initially dry – estimates of typical initial soil water contents for each soil are now used. The porosity values are weighted according to the
proportion of the farm occupied by the respective soil types. The farm average rise or fall of
the watertable is estimated as the net farm recharge divided by the weighted farm porosity.

Preliminary model runs in both the simulation and optimisation modes have commenced for
four representative farms in the Murray Valley. This exercise has highlighted the need for
improved model inputs and for model improvements to better customise the model to Murray
Valley conditions.

Dr Fei Zhou commenced as a Rice CRC funded programmer for this project. He has
evaluated the relevant software and hardware resource at Griffith and identified and
commissioned computer systems for his programming role. He has made good progress on
developing a new weather data management system to replace the current system on the Vax
computer, which is not Y2K compliant.

A training module on net recharge management for the Coleambally Land and Water
Management Plan Education Program was developed and presented to about 30 farmers

Soil salinity assessment and prediction model (1202)

Project Leader:
Mr Ary van der Lely
NSW Department of Land and Water Conservation
Griffith

The aim of the project is to review the Soil Salinity Assessment and Prediction Model used
for Land and Water Management Plans in NSW and to consider alternative methods for
assessing trends in the extent of landscape soil salinity.

Progress

Current soil salinity in each sub-regional area is considered to be the performance indicator of
past high groundwater level effects. Analysis of past groundwater behaviour and linking
with soil salinity data therefore should provide trend estimates which may be used for
prediction purposes if management factors can be accounted for.

A lump sum parameter groundwater balance model including recharge and discharge factors
was used to estimate the positive and negative effects of land and water management options
on the areas with watertables within specific categories.

The review of the methodology produced three alternatives for salinity assessment.

1. Curves.
   Simple prediction curves based on salinity status and period of high watertables may be
   produced for each high watertable category. The curves are then extrapolated. This
   relatively easy assessment has merit but suffers the disadvantage that it relies on
   regression analysis and a number of questionable assumptions.
2. **Statistical.**
The soil salinity assessment may be based on an optimisation model of all salinity data for all sub-districts, using groundwater depth and hydro-geological factors in each sub-district as calibration coefficients. This approach produces a very credible set of estimates for soil salinity but unfortunately this model is not suitable for estimating the beneficial effect of changed management due to land and water management options.

3. **Process Model.**
The current salinity accumulation in the root zone is a function of salt accumulation due to irrigation added salt, capillary rise and run-off processes over the period that the watertable has been high. The model developed and calibrated against field salinity results allowed the incorporation of Land and Water Management Plan option effects. Unfortunately it appeared to be sensitive to key factors affecting the net upward flux of salts over time, reducing its value as a suitable predictive tool for longer periods.

The various factors of the groundwater balance were considered. It is clear that the huge spatial variation of many factors critical to the assessment can never be captured fully for a regional assessment. Inevitably, simplified models are preferred. Since none of these produces fully satisfactory results, a combination of approaches may be needed for performance monitoring analysis.


**Improving the water use efficiency of rice (1204)**

**Project Leader:**
Mr John Thompson
NSW Agriculture
Deniliquin

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

**Progress**

Temperatures were favourable throughout the 1998/99 growing season. Grain yields from the raised beds were 4% below those from conventional aerial sowing. The yield from an early sowing (Millin) was reduced by 8%. Duck damage precluded a result from the late sowing. Preliminary water use figures indicate that none of the strategies employed significantly lowered water use on the red brown earth.
Quantifying and maximising the benefits of crops after rice (1205)

Project Leader:
Dr Liz Humphreys
CSIRO Land and Water
Griffith

The project aims to:-

* determine farmers’ perceptions of:-
  - constraints to growing crops/pastures immediately after rice;
  - factors leading to successful production of crops after rice;
  - impacts on sustainability (environmental, economic); and

* quantify the impacts of growing wheat directly after rice on:-
  - crop water use and its source (rainfall, stored soil water, upflow from the watertable);
  - net recharge of the watertable;
  - distribution of salt in the root zone; and
  - productivity and water use efficiency of the rice-wheat cropping system.

Progress

* Survey

About 300 rice growers responded to a survey on growing crops after rice. 43% of the respondents regularly grow crops immediately after rice harvest, 20% sometimes, 17% rarely and 20% never. Only 20% of the farmers who regularly grow crops after rice do this on 100% of their rice areas each year.

* Field experiments

In April 1998 a replicated field experiment was installed on a red clay loam to compare three treatments imposed after rice harvest – (1) stubble retained fallow, and (2) and (3) stubble burnt, wheat sown on 24 April and 29 June 1998.

Total dry matter in the early sown wheat was higher than in the late sown wheat throughout the season. Grain yield was also higher in the early sown wheat (4.7 t/ha vs 3.8 t/ha at 12% moisture).

In mid April the depth to the watertable in all treatments was around 1.45 m. By the end of June the watertable in the early sown wheat was significantly lower than in the other treatments (Fig.2). The watertable in the stubble retained and late sown wheat treatments was much more responsive to significant rainfall events, while the watertable continued to decline in the early sown wheat until September. The decline occurred due to higher water use by the early sown crop as evidenced by soil drying. A similar effect was observed in the late sown crop as the season progressed. The sudden rise in the watertable in September in the early sown wheat was probably due to a rise in regional groundwater pressures coincident with the start of the irrigation season. This will be investigated further and also the possibility of lateral movement of water between the plots, which would confound the results. The soil profile with stubble retained remained saturated throughout the season, whereas soil water
depletion of 60-100 mm occurred in the wheat treatments (Fig.3). Determination of upflow and/or recharge is underway. Preliminary estimates suggest that the wheat crop used some water from the groundwater whereas there was a small amount of net recharge in the stubble retained fallow over the wheat season.

The 1998 experimental site was flood-irrigated on 1 April 1999 to refill the soil profile. Fallow (same plots as in 1998) and planted treatments will again be compared during 1999, hopefully under significantly different seasonal conditions. Monitoring of piezometric and watertable conditions, both within and between the treatments, has been intensified to try and separate regional, lateral and treatment effects on the hydrology of each treatment.

A second experiment comparing the fallow and planted treatments has been installed on a heavier soil type as the soil at the initial site appears to be relatively permeable. Wet weather in autumn delayed rice harvest and establishment of the wheat. The wheat also had to be resown on 28 May 1999 due to waterlogging caused by rain shortly after the first sowing on 20 May 1999.

In 1998 mole drains with a range of configurations (slope, diameter) were installed after rice harvest in large bays on a red clay loam and a grey self-mulching clay soil. There was no effect of the moles on depth to the watertable (always deeper than 1 m) at either site. The plot header data suggested a 27% yield increase with mole drains on the grey clay soil but no response on the red soil. If the yield response was real then it may have been as a result of soil loosening and improved aeration. Christen et al. (1995) measured yield increases of 8% and 9% for wheat after rice with mole drainage on grey and red clay soils respectively.

Fig. 2. Effect of sowing wheat after rice on depth to watertable
Postgraduate studies – modelling rice-wheat cropping systems (1206)

Project Leader:
Dr Liz Humphreys
CSIRO Land and Water
Griffith

The aims of the project are to:-

* review literature on rice-wheat cropping systems concentrating on semi-arid climates and crop/soil water/watertable interactions;

* compile existing data from rice-wheat cropping in southern Australia and use these data to calibrate and validate the CERES Wheat and SWAGMAN Destiny crop models; and

* predict the impact of wheat after rice on recharge and root zone salinity for a range of seasonal conditions, watertable depths, soil types, rates of leaf area development and management.

Progress

A part-time postgraduate student (Mr David Smith) was recruited to commence in April 1998. In May 1999 Mr Smith withdrew from his postgraduate studies, however he will continue to carry out the model calibrations, validations and simulation as a CSIRO employee with funding assistance from the CRC.

Six southern NSW irrigated and non-irrigated wheat data sets have been compiled and used to calibrate and validate the CERES Wheat and SWAGMAN Destiny models. Model refinement and validation are well underway (eg Table 1, Fig. 4). Validation was accomplished by
modifying the genetic coefficients of the varieties to reflect the observed flowering and maturity dates. The modified genetic coefficients were then applied to independent data sets for verification of the validation. Once final validation is complete, model predictions of the impacts of wheat after rice on yields, watertables and root zone salinity will be simulated for a range of seasonal conditions, watertable depths, soil types and management options. It is envisaged that over the next 12 months, this project will identify constraints and keys to growing crops after rice and will quantify the impacts on watertables and root zone salinisation.

Table 1: Compilation of six wheat data sets on three soil types depicting comparison with the CERES and SWAGMAN Destiny models.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Obs</th>
<th>CERES</th>
<th>Destiny</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yooroobla Clay*</td>
<td>4.0</td>
<td>4.1</td>
<td>4.0</td>
</tr>
<tr>
<td>Hanwood Loam</td>
<td>5.9</td>
<td>5.8</td>
<td>5.7</td>
</tr>
<tr>
<td>Mundiwa Clay Loam</td>
<td>5.5</td>
<td>5.4</td>
<td>5.4</td>
</tr>
<tr>
<td>Mundiwa Clay Loam*</td>
<td>4.4</td>
<td>4.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Beelbangara Clay Loam*</td>
<td>4.2</td>
<td>4.3</td>
<td>4.1</td>
</tr>
<tr>
<td>Beelbangara Clay Loam*</td>
<td>3.4</td>
<td>3.4</td>
<td>1.9</td>
</tr>
</tbody>
</table>

* these crops were sown immediately after rice harvest

Figure 4: Time course scenario of biomass accumulation using the CERES Wheat model.
1.3 Surface Drainage Management

Sub-Program Leader:  
Mr Leigh Gray  
CSIRO Land and Water  
Griffith

Development of area specific Environmental Quality Objectives (EQOs) and investigation of the impacts (beneficial and non-beneficial) associated with rice production within the MIA (1301)  
Fate and amelioration of applied organic contaminants associated with rice agriculture (1302)

Project Leader:  
Mr Leigh Gray  
CSIRO Land and Water  
Griffith

Aims of the projects are as follows:-

(1301)  
To develop area specific Environmental Quality Objectives that address the real toxicity to aquatic organisms contained in drainage waters. Specific focus of this project will be on preventing algal blooms and investigating the synergism/antagonism associated with pesticide mixture toxicity.

(1302)  
Process study to determine the fate and potential steps that may be taken to ameliorate the effects of field applied pesticides. A critical feature of this Sub-Program will be an investigation into the affects upon, and the cycling of pesticides by, the microbiological community contained within soil.

Progress

Mr Leigh Gray was appointed as Project Leader in October 1998. A review of the existing knowledge concerning pesticide research within the MIA was conducted and has now been completed. Extensive consultation with interested government agencies, commodity groups and farmers was undertaken and has been incorporated into the proposed projects.

It is anticipated that the projects will commence early in 2000. Both of these projects will input directly into Land and Water Management Plans and will add detailed information to the proposed Australian Water Quality Management Guidelines 1999 (currently under review).

Bioremediation of pesticide residues in irrigation drainage waters (1303)

Project Leader:  
Dr John Oakshomme  
CSIRO Entomology  
Canberra
This project is a PhD studentship awarded to Ms Rama Heidari. Ms Heidari began in June 1998.

This project is part of CSIRO’s overall pesticide bioremediation program which is conducted collaboratively with Orica Ltd, which holds the commercial rights. The major aim of the project is to develop enzyme technologies for cleaning up pesticide residues in waste waters. The focus of Ms Heidari’s work is to find enzymes suitable for certain carbamates and, to a lesser extent, pyrethroids.

**Progress**

Work is progressing on schedule with one promising enzyme already identified.

### 1.4 Groundwater management at the regional scale

**Sub-Program Leader:**
Mr Charles Demetriou  
NSW Department of Land and Water Conservation  
Parramatta

**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.

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.

**Progress**

1. *Salt transport in regional scale*
This part of the work is being undertaken by Mr Peng Xu, a PhD student from the Centre for Advanced Numerical Computation in Science and Engineering (CANCES) at the University of New South Wales. Dr Yaping Shao is the University of New South Wales supervisor.

The objective of the study is to develop an integrated modelling system which will consist of a high resolution limited area, atmospheric model developed at the School of Mathematics, University of New South Wales, Atmosphere-Land Surface Interaction Scheme (ALSIS) and the groundwater flow model MODFLOW. The integrated model will be tested and verified using the data from the already developed Wakool Mike SHE based model. Then the model will be applied to rice growing areas such as the Lower Murrumbidgee Irrigation District.

The PhD student started work on the project in August 1998. The first year of the study mainly focused on the following:

* improvement of the atmospheric model;
* improvement of the soil model;
* implementation of the groundwater model;
* development of the first stage of the integrated model; and

The atmospheric model HIRES as well as the soil model ALSIS have been improved. MODFLOW has now been coupled with ALSIS. ALSIS was used to produce drainage from the unsaturated soil, which is used as recharge in MODFLOW. The coupled model surface and groundwater hydrological processes in the region, MODFLOW and MOC3D (three-dimensional Method of Characteristics) were used to simulate the groundwater flow and salt transport in the test area. The data for the Wakool catchment have been converted from Mike SHE files into MODFLOW files.

2. **Salt transport in farm scale**

This part of the work is to be undertaken by a PhD student from the National Centre for Groundwater Management at the University of Technology Sydney (UTS) under the supervision of Mr Noel Merrick.

The objectives of this part of the project are to:-

* examine the dynamics of groundwater level and salt load 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 (10-50 m discretisation) and at a short time scale (1-7 days stress period);
* investigate coupling of an unsaturated zone code with MODFLOW;
develop a management model at the paddock scale to address options for reduction of salt discharge to water bodies; for example - small scale interception schemes, recycling of drainage water, groundwater mixing with supply waters.

To date, this PhD position remains unfilled. UTS will continue advertising this position. It is agreed that if it is not filled by December 1999, the Sub-Program committee will convene to decide on a different approach to achieve the project’s objectives.

Although the PhD position was not filled, the data collection is progressing according to plan. The test site (farm) was selected, the geophysics 3D-resistivity image hardware and software were acquired and relevant personnel have become familiar with its use. Four field trips were carried out during the year and readings were taken using both the resistivity 3D image as well as EM34. On two occasions, complementary EM31 readings were taken as well by Mr Geoff Beecher (NSW Agriculture). The readings from the first field trip have been analysed and the results look very promising.

**Development of management models to assist in water policy reform in rice-based irrigation areas (1403)**

**Project Leader:**  
Dr Shahbaz Khan  
CSIRO Land and Water  
Griffith

Large rice cultivation areas in Australia have experienced rising watertables and soil salinity which threaten the sustainability of irrigated agriculture. To address the sustainability issues Land and Water Management Plans are currently being developed and put into operation in NSW. These plans include actions aimed at reducing watertable rise by minimising groundwater recharge or increasing discharge from the aquifers. Improving irrigation efficiencies and management practices can reduce the groundwater recharge but there is a need to evaluate and differentiate the impacts of these measures from climatic factors such as a long sequence of wet years. The groundwater discharge on the other hand demands that there should be minimum downstream environmental, social and economic impacts. The efficiency and economic viability of these plans depend on their ability to decrease the soil salinity hazard and hence increase agricultural productivity. The effectiveness of these plans will depend on the assessment of different management options and quantification of climatic impacts on controlling waterlogging and salinity. This objective can be achieved only through an integrated set of hydrological, groundwater and Geographical Information System (GIS) models to incorporate spatial variability and to determine the impact of farm scale management policies on groundwater and soil salinity on a regional scale.

The aim of this project is to develop a recharge estimation model which will differentiate and quantify the rainfall and irrigation components of recharge and the effect of direct evaporation from shallow watertables. In addition to a recharge estimation model, regional and critical area (farm scale) groundwater flow and solute transport models linked with GIS databases shall be developed for the irrigation areas. These models shall be used to evaluate the local and downstream impacts of a number of management concepts, eg- drainage, conjunctive water use and sustainable hydraulic loading. Application of these models in the Coleambally and Murrumbidgee Irrigation Areas will enable development of guidelines for effective
implementation and monitoring of Land and Water Management Plans. This project will involve strong interaction between CSIRO Land and Water, Department of Land and Water Conservation, Charles Sturt University, Murrumbidgee Irrigation Limited and Coleambally Irrigation Corporation.

**Progress**

The base work for the above project has been completed in terms of forming a project team from CSIRO Land and Water, DLWC and CSU in close association with Coleambally Irrigation Corporation and Murrumbidgee Irrigation Limited. A work plan for the development of management models and Land and Water Management Plans (LWMPs) has been formulated. Project overlaps and links with other CRC projects have also been identified. Review of related reports, data and models has been initiated.
## Milestones

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.1 Measurement and Mapping</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement of soil suitability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X RIRDC project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Better prediction of groundwater recharge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- review indices of recharge</td>
<td>X ✓</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- experiments</td>
<td>X ✓</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- data collection</td>
<td>X ✓</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- reporting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Water management practices on irrigation farms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- evaluating water management practices</td>
<td>X Deferred</td>
<td>X Not CRC - external funding (from LWRRDC) being sought by CSIRO Land and Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Losses from farm channels</td>
<td>X Commenced</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Remote sensing of crop types</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- appoint student</td>
<td>X Not Achieved</td>
<td>Not achieved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- review current methods</td>
<td>X Not commenced</td>
<td>X Not commenced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- collect existing data</td>
<td>X Not commenced</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- develop and test methods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- complete project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Classification of irrigated soils by remote sensing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- review</td>
<td>X ✓</td>
<td></td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- acquire and compile existing data</td>
<td>X Deferred</td>
<td>X Deferred</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- conduct research to fill gaps</td>
<td>X Not commenced</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- develop derivative classification maps</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>- integrate technology with existing data systems</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>1.2 Net recharge management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-farm agronomic options</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- model testing and refining</td>
<td>X Commenced</td>
<td>X ✓</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>- economic model developed</td>
<td>X Commenced</td>
<td>X ✓</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>- options assessed</td>
<td>X Commenced</td>
<td>X ✓</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Improved soil salinity assessment and prediction model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- model testing and refinement</td>
<td>X ✓</td>
<td></td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milestone</td>
<td>Year 1</td>
<td>Year 2</td>
<td>Year 3</td>
<td>Year 4</td>
<td>Year 5</td>
<td>Year 6</td>
<td>Year 7</td>
</tr>
<tr>
<td>-----------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Hydraulic loading policy assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- hydraulic loading review</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- available models reviewed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- development and application of new models</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved water use efficiency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- field trials complete</td>
<td>X ✓</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crops following rice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- survey</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- field monitoring/trials</td>
<td>X ✓</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- review/modelling</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- alternative crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compaction options</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- project evaluation</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- alternative techniques assessed</td>
<td>X No further work proposed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3 Surface drainage management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appointment of staff</td>
<td>X Deferred</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downstream impacts on the environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- biodiversity survey completed</td>
<td>X Commenced in Prog 2.4</td>
<td>X Deferred</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- development of techniques to minimise pollutants</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-farm management options</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- desktop study completed</td>
<td>X Deferred</td>
<td>X Deferred</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- field trials to assess technology</td>
<td>X Deferred</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- FILTER technology assessed</td>
<td>X Commenced</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- DSS system developed</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional management options</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- redundancy of measures defined</td>
<td>X Partially commenced</td>
<td>X Partially commenced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- region wide options defined</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- residual toxicity definition</td>
<td>X Partially commenced</td>
<td>X Continuing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- rapid tests developed</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- farming system proposals</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- developed and extended</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4 Groundwater management at the regional scale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimation of salt transport and salinisation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- recharge estimation and mapping</td>
<td>X Commenced</td>
<td>X Continuing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- transport models</td>
<td>X Commenced</td>
<td>X Continuing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milestone</td>
<td>Year 1</td>
<td>Year 2</td>
<td>Year 3</td>
<td>Year 4</td>
<td>Year 5</td>
<td>Year 6</td>
<td>Year 7</td>
</tr>
<tr>
<td>----------------------------------------------------</td>
<td>-------------------------</td>
<td>---------------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>- nutrient export and management</td>
<td>X Continuing</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managing groundwater systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- shallow groundwater pumping options</td>
<td>X Commenced</td>
<td>X Continuing</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- deep groundwater pumping options</td>
<td>X Commenced</td>
<td>X Continuing</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Management model to assist reform</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- allocation strategies optimised</td>
<td></td>
<td>X Continuing</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- integrated surface and groundwater models developed</td>
<td>X Commenced</td>
<td>X Continuing</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>- salt and nutrient strategies included in models</td>
<td>X Commenced</td>
<td>X Continuing</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

X = To be completed (in some cases this exercise is repeated over several years).
✓ = Achieved (if not achieved, status provided)
RIRDC have historically funded applied agronomy research projects. They continue to fund applied projects in areas such as sowing methods, nitrogen fertilisation, water management, crop nutrient management and crop protection. Rice CRC Program 2 addresses more 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.

During the second year of this Program significant data were collected on soils and their analysis, the growth of rice plants subjected to cold stresses, developing techniques to manipulate rice minerals and new approaches to crop protection. The direction of the Program has not been varied but many valuable linkages have been initiated between Rice CRC projects, RIRDC projects and with scientists at Australian and International Research Centres.

Specific goals are:

* an improved understanding of the changes in soils used to grow rice;

* an enhanced understanding of the ability of the rice plant to respond to changes in its environment, particularly cold at the reproductive stage;

* the development of tools that can be used to monitor soils, the rice plant and its environment; and

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

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.

An inventory of the current status of the soil resource in terms of long-term trends in fertility as well as spatial variability within fields is needed 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

Nitrogen is the key nutrient in the rice production system of NSW and better prediction methods are needed to optimise productivity while minimising excessive use. A tissue testing service is available for mid-season nitrogen applications but early nitrogen is more critical for optimum yield.

In this project, with Postdoctoral fellow Dr Craig Russell, we aim to develop a rapid strategic soil nitrogen (N) test for aerially sown flooded rice (Oryza sativa). Both a physical (Near Infrared Reflectance, NIR) and a chemical (hot 2M KCl extract) test have been evaluated for their abilities to predict rice N uptake at panicle initiation (PIN) from field control plots. The project follows three lines of research:-

1. attempts to calibrate the physical and chemical tests;  
2. extensive evaluation of NIR methodology; and  
3. implementation and refinement of the most superior soil N test.

Calibration of the soil N tests will have three phases:-

1. preliminary calibration for archived soils with complimentary PIN data;  
2. extended calibration from the inclusion of a large number of soil types/histories with complimentary PIN data; and  
3. investigating the mechanism of the calibrations from a comprehensive analysis of soil properties.

**Progress**

Four soil N tests have been evaluated for their ability to predict PIN from the soil of control plots in prior district N trials. These tests were - aerobic incubation, anaerobic incubation, 2M hot KCl extraction and NIR spectral analysis. Only the NIR test ($R^2 = 0.85$) was able to predict more than 25% of the variation in PIN. It is concluded that soil NIR spectra correlate strongly with soil N supply and due to its rapid acquisition and analysis infrared techniques are to be pursued for the development of the CRC soil test. To verify this test 120 control plots (8 x 8 m) were set up and sampled (0-0.1 m soil) on 45 farms throughout the Riverina in September. These sites were sampled for biomass dry matter and N at panicle initiation and maturity. Preliminary analysis of the PIN data confirms its strong correlation with soil NIR spectra.
The implementation of the NIR-based “CRC rice soil test” for the prediction of soil N supply is likely in the next 12 months.

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

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

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**

Ms Sarah Spackman (PhD student) is working with Dr David Lamb on the project.

Four trial sites were established. At each trial site, field data were acquired for the project, including soil and multi-temporal plant samples, spectral radiometric measurements and airborne digital images. Crop yield data have now been acquired using both harvester-based yield mappers and hand cuts.

The model maNage rice has been chosen as the specific model in which to integrate the aerial imagery. At present the model is being converted from Fortran code into an Excel spreadsheet and limited to particular inputs. An examination of possible model inputs from airborne-derived imagery is underway.

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

**Project Leader:**
Dr Harnam Gill  
NSW Agriculture  
Yanco

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 July 1998, a procedure for sampling soil from rice paddocks within the Murrumbidgee Irrigation Area, Coleambally Irrigation Area and the Murray Irrigation Districts was prepared. District agronomists and farmers helped in the identification and selection of a range of sites typical of the Australian rice soils, intensity of rice cultivation, crop rotations for growing rice and the comparison between cut and fill areas on some rice paddocks.

Soil sampling effectively started in August and continued until the end of October 1998. During this period heavy rains disturbed the sampling schedule considerably and not all selected farms were sampled.

Each of the selected rice paddocks, or the cut and fill areas within a paddock, were sampled separately to collect a surface (0-10 cm) and a sub-surface (10-30 cm) sample. Each sample is a composite or a mixture of 20 samples drawn from as many locations within a rice paddock or cut and fill areas regardless of their size. These locations were recorded using global positioning system (GPS) equipment. In all, 324 soil samples in 59 rice paddocks were collected from 53 rice paddocks in the Coleambally Irrigation Area and the Murrumbidgee Irrigation Area. In addition, 50 soil samples were also collected from a long-term experiment at Deniliquin.

After a thorough mixing, about 1.0 kg soil was stored in high density polyethylene bottles for future use. Sub-samples are now being analysed for pH, E_C, C, N, S, exchangeable cations and total P. Analysis of these soil samples for other parameters (CEC, available P, Fe, Mn, Zn, and Cu) is being planned and expected to be completed by August 1999. The next round of sampling, especially the Murray Irrigation Districts, will start in August 1999.

**Rotation Trials (2105)**

**Project Leader:**
Mr John Thompson  
NSW Agriculture  
Deniliquin

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 ricegrowing system. Saline water is applied to the crops in the rotation phase and effect on yield of all crops, including rice, in the rotation is recorded.

**Progress**

One saline irrigation was applied to the subterranean clover in spring and two in the autumn. Rice yields (12.3 t/ha) were not affected by the application of saline groundwater to the previous wheat and subclover phases. Soil samples have been collected from this site for Project 2103.
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 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

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

Mr Tim Farrell (Research Agronomist) has made good progress with screening a range of 36 rice varieties for cold tolerance in both field and glasshouse conditions.

* Glasshouse

The series of three controlled environment experiments were conducted during the 1998/99 rice season with good results. Two of the glasshouse experiments investigated genetic variation in low temperature tolerance in 36 and 18 genotypes respectively. These data have been combined to identify seven cold tolerant genotypes that consistently performed better than the Australian cultivars.

Cold tolerance was confirmed in two lots of testing, at two nitrogen rates. The cold tolerant varieties include Liman and Pavlovsky (from Russia), Plovdiv 22 (Bulgaria), Akihikari and...
Haenuki (Japan), HSC55 (Hungary), M103 (California). Low temperature reduced harvest index of these tolerant varieties by only 20% compared to 50% for the major Australian varieties.

The role of pollen numbers in conferring cold tolerance in Japanese varieties has been confirmed. Amongst Japanese varieties grown in low temperatures those with large pollen numbers had less low temperature damage.

* Field work

Attempts to confirm tolerance in the field were thwarted by above average temperatures during the 1998/99 rice season. A series of nine sowing dates including a replicated trial of 30 genotypes was conducted. In each plot key measurements of flowering date, pollen number, sterility, final biomass and grain yield were measured. Analysis of data from this work is ongoing.

We have successfully measured spikelets at flowering for total engorged pollen number and anther length.

A new technique to prepare pollen grains for automated counting has been developed. The anthers are bathed in a warm solution of cellulase overnight prior to counting. This reduces the time required to remove the pollen grain from the anthers and reduces the stickiness of pollen grains to each other. This chemical treatment has allowed a greater number of pollen grains to be analysed each day.

An image analysis system measures anther length and pollen number at flowering. The system includes a video camera attached to a personal computer that obtains an image through a dissecting microscope. This automation of counting pollen grains enables greater sampling of the anthers and replicates, ensuring a greater precision in measurement.

* Yield Modelling

The visit from Dr Ryoji Sameshima, a Japanese scientist, enabled an industry level rice model to be produced using the yields of the variety Amaroo in each of the three irrigation areas over the last 10 years. This project has developed a daily time step model that integrates seasonal temperature and radiation to predict industry yield level. The average error of prediction will be improved with further refinements. The fit of the model was limited by not using actual ranges of sowing dates but by using a fixed sowing date for each year. Future enhancements will include the addition of a range of sowing dates for each year’s input.

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

**Project Leader:**
Dr Bruce Sutton
University of Sydney
Sydney

The aim of the project is to provide a complete description of the development of the anther at least up to early microspore development, using light and electron microscopy (EM).
It is becoming clear that the development of reproductive tissues in rice is very sensitive to a range of stresses which the plant may encounter, resulting in abortion of the male (pollen), female (ovary) tissues or both. In this respect, rice appears to be much more sensitive than other C3 cereals such as wheat.

Chilling damage is a result of the plant aborting pollen development after a short exposure to mild (12-15°C) chilling, with the female parts remaining undamaged (Satake and Koike, 1983). The sensitive stage for this response appears to be late in meiosis, around the stage of tetrad release. Of all the possible mechanisms that may be responsible for this result, we are currently examining two broad areas. Is the chilling damage a direct effect on the meiotic cells or is it a response to changes that chilling causes in the integrated functioning of the anther?

Development of the anther at these stages is not well described in the literature. Most information available is restricted to the meiocytes and the tapetum and there is little knowledge about the other tissues; the middle layer, endothecium, epidermis and anther filament.

* Light microscopy

Most of the information that we have about the anther is derived from electron microscope images of fixed and sectioned material and this reveals little of the dynamic nature of reproductive development. Our aim has been to view some of the processes using light microscope technique in whole anthers and, where possible, in whole living anthers. Fluorescent stains for cell nuclei, cytoskeleton, mitochondria, cell viability and tracers of phloem transport and cell-to-cell communication are valuable tools that to date have been ignored in the literature for studies of anther biology.

In Assoc Prof Robyn Overall’s laboratory we are using confocal microscopy, which allows optical sectioning through intact living tissues, in conjunction with fluorescent stains, to map at the cellular level some of the fundamental developmental and physiological processes in pollen formation. These techniques will also allow us to directly observe anthers and isolated meiocytes during exposure to chilling on the stage of the confocal microscope.

We have been working in collaboration with Dr Norman Darvey’s group at the Plant Breeding Institute (PBI), Cobbitty to develop suitable culture techniques to support isolated anthers through meiosis to the tetrad and microspore stages of development. (Sub-Program 3.3)

* Electron microscopy

Electron microscope images of rice anthers have been a familiar feature of the literature over the last few decades, yet a complete developmental sequence of quality images has been lacking. A developmental sequence from premeiosis to pollen formation is being built up with the aim of comparing these images with those from chilled anthers. The tapetum and meiocytes are being targeted as the cell layers where critical aspects of physiology are likely to be disrupted by chilling but close attention is also being paid to the other tissues of the anther. Electron microscope techniques will also be used for immunocytochemistry localisation of specific structural components.
A particularly important part of structural development is the deposition and dissolution of callose in the anther. Callose is a β−1,3-D-glucan that is deposited in a thick layer between the plasmalemma and cellulose cell wall of meiocytes prior to meiosis. Isolation of the meiocytes is thought to be necessary to confine meiosis within these special cells and may play a role in synchronising cell division among the meiocytes. Indeed, timing of the formation and dissolution of this callose wall seems to be critical. The literature suggests that in some plants, early dissolution of callose by release of β−1,3-D-glucanase can lead both to pollen abortion and tapetal hypertrophy as the tapetum absorbs the glucose released by callose degradation (Worrall et al, 1992). In addition to establishing a developmental sequence of images at the EM level, Mamun is studying callose metabolism in rice anthers to determine if a similar pathway of disrupted deposition and/or dissolution occurs in response to chilling. Immunocytochemistry at the EM level will be used to localise both callose and β−1,3-D-glucanase activity.

![EM image of section through a post-tetrad rice anther lobe showing the epidermis ep, endothecium en, middle layer m, locule space l, and microspore mi.]

*Pathways of substrate supply*

The process of anther development and pollen formation is one which places heavy demands on substrate supply. Literature on the tapetum concentrates on its role in supplying metabolites to the microspores in the later stages of pollen development, particularly those associated with pollen wall (exine) development but is relatively silent on the issue of supply of substrates, particularly energy substrates in the early chilling sensitive stages of pollen development. We are pursuing this to determine whether chilling may be causing a disruption in substrate supply.

Pathways of substrate movement within the anther are being mapped by passive fluorescent apoplastic and symplastic tracers as well as direct microinjection into anther cells. It seems likely that sugars diffuse passively from cell to cell via plasmodesmata in the epidermis and endothecium throughout most of anther development (Clément and Audran, 1995; Imlau et al, 1999; see Fig. 6). However movement of sugars in the inner anther is likely to start out as a diffusion process, becoming energy dependent at the cold sensitive meiosis to microspore
period of development. This work being done by Dr Laurence Cantrill and Ms Karen Herbert should provide clues on potential sites for invertase dependent sucrose transport.

Alongside tracer studies in the anther, substrate supply, typically sucrose, is being studied by microautoradiography after rice leaves have been exposed to $^{14}$CO$_2$. These experiments, only recently commenced by Dr Bruce Sutton and Dr Brent Jacobs, will also allow us to begin to answer the question of what tissue in the rice plant is sensing the chilling temperature.

References:

2.3 Mineral Nutrition and Grain Quality

Sub-Program Leader:
Dr Graeme Batten
NSW Agriculture
Yanco

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 comprises three scientists, 1 visiting scientist, 2 technical officers, 1 PhD student and 1 Honours Student.

**Rice Plant Nutrition and Physiology (2301)**

**Project Leaders:**
Dr Graeme Batten  
NSW Agriculture, Yanco  
Dr Lindsay Campbell  
University of Sydney, Sydney

The trace elements iron and zinc are receiving attention from nutritionists. In this project Mr Rob Duncan aims to establish links between trace element distribution in the rice plant and grain quality, as part of a higher degree.

Studies will include the investigation of:-

* time-course accumulation of Fe and Zn in rice grains;  
* within-panicle variation in Fe and Zn content of rice grains; and  
* genotypic variation in Fe and Zn content of rice grains at physiological maturity.

**Progress**

Preliminary laboratory studies indicate that it will be necessary to develop suitable analytical protocols for the analysis of field samples. These studies will clarify if it is necessary to decontaminate field samples prior to analysis of Fe.

**Mineral requirements (2302)**

**Project Leader:**
Dr Graeme Batten  
NSW Agriculture  
Yanco

1. **Manipulation of protein and minerals in rice grain**

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

**Progress**

The consequences of raising protein content on grain size, other minerals, grain colour and cooking quality, are being examined by Ms Zara Evans, Honours Student, University of Sydney. In March 1999, urea-N was applied at the flowering stage to rice in plots at Yanco. Grain protein was increased by about 30%.
A technique for culturing individual rice panicles, detached post flowering, is being
developed by Mrs Tina Dunn (Technical Officer). This will facilitate the manipulation of
nitrogen and mineral deposition in grains and help in understanding grain quality.

In early studies grains were small and contained very high concentrations of protein.
Modifications were made to the growth media and it is now possible to grow grains with
protein (N x 5.95) in the range from very low (3-4%), through high (20%) to extremely high
(45%). Modified solutions are now being tested to produce grains with various
concentrations of macro and micro elements.

As a follow up to the Honours project studies by Mr Daryl Hill (1998), field experiments
were set out with Mg and K fertiliser applications aimed at modifying mineral concentrations
in grain under field conditions. Analyses of the grains has just commenced.

2. Importance of crop sowing technique on plant establishment and production (with Mr
Yukihiro Hamada – Visiting Scientist, Japan)

In the first comparison in more than 20 years, 16 commercial crops which had been sown
using aerial, sod and combine techniques were monitored. The establishment of sod sown
crops was depressed by the presence of dry matter remaining from the previous pasture crop.
Plant and grain samples are being processed to determine N utilisation and grain quality.

Mr Hamada’s visit has prompted the following questions which the CRC may wish to
investigate:-

* why, compared to rice crops in Aichi Prefecture in Japan, do Australian rice crops produce
about three times as many tillers at maximum tillering but achieve only about 50% more
panicles at harvest;

* what indicators can be used to determine when to flush-irrigate sod and combine sown
crops?

3. Fertiliser – genotype studies (with Mr Yukihiro Hamada – Visiting Scientist, Japan)

At Yanco Agricultural Institute, the Australian variety Amaroo and the popular Japanese
variety Koshihikari were sown with no fertilisers or a range of rates of N applied as urea or
coated (slow release) urea in contact with the seed. Amaroo proved more tolerant to either
fertiliser placed with the seed. Further studies are being planned in both Japan and Australia
to gain an understanding of these genotypic variations.

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

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

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

Straighthead is a physiological disorder that can cause serious yield loss in some situations. It is recognised by the symptoms that vary from mild sterility to severe distortion of the panicles on affected plants. Affected florets often have typical “parrot beaked” distortion. In its most severe form, the affected plants will have virtually no panicle development, and the leaves very dark green. It is not a widespread problem but there are usually some affected crops each year. It appears to be more prevalent in warmer years. The affect of straighthead on grain quality has never been studied.

Soil, shoot and grain samples were collected by Mrs Robyn Trolahl and Mr Peter Beale from straighthead and unaffected (less affected) areas in 18 commercial crops together with information for each site, at about grain maturity ie. March – May 1999. In the glasshouse, straighthead has also been induced by the herbicide mono sodium methyl arsenate (MSMA).

In both studies plants affected by straighthead were shorter and had very poor yield due to severe reduction in grains/panicle. The rice variety Koshihikari is very susceptible to this disorder, especially when grown after good pasture or where stubble was incorporated.

The plant and grain samples and data collected for each crop will provide a basic understanding of the importance of straighthead, some indications of a cause and possible remedies.

2.4 Sustainable Crop Protection

Sub-Program Leader:
Dr Ric Cother
NSW Agriculture
Orange

In order to address community concerns about the use of agricultural chemicals and the environment, this Sub-Program aims to minimise chemical use while maintaining protection of rice crops from insect pests, diseases and weeds. This may be achieved through alternatives or enhancement of chemical control by understanding the biology of insect pests, diseases and weeds of rice and their natural enemies.

The genetic structure of populations of the weed biocontrol fungus *Rhynchosporium alismatis* is being assessed by PhD student Mr Wayne Pitt at CSU, Wagga Wagga. Chlamydospires of this fungus have been described for the first time by visiting French student Mr Vincent Lanoiselot. Chlamydospires have the potential to provide a more robust form of inoculum for field application.

*Host range and virulence of Rhynchosporium alismatis (2401)*

Project Leader:
Dr Ric Cother
NSW Agriculture
Orange
The aim of this project is to expand the host range of this biological control agent to other Alismataceae weeds in rice fields.

**Progress**

Forty isolates of *R. alismatis* were assayed for pathogenicity against two host (*Damasonium minus* - Starfruit, *Alisma plantago-aquatica* - Waterplantain) and two non-host (*Sagittaria graminea* and *S. montevidensis* - Arrowhead) weeds. DNA from these isolates has been extracted and quantified and preliminary PCR (polymerase chain reaction) using REP (repetitive extragenic palidromic) and ERIC (Enterobacterial repetitive intergenic consensus) sequence primers undertaken. REP sequences completed so far, however, have shown only minimal variation among isolates of the same genus and species. In addition to these sequences, ITS (Internal transcribed spacers), IGS (Intergenic spacers) and SSR (Single sequence repeat) primers are being assessed to determine genetic variation within the pathogen population. The objective is to relate this to (i) host affiliation and (ii) geographic origin.

**Alternative inoculum in *R. alismatis* (2402)**

**Project Leader:**
Dr Ric Cother
NSW Agriculture
Orange

The aim of the project is to examine alternative inoculum sources for this biocontrol agent.

**Progress**

The thick-walled survival structures (chlamydospores) produced by this biocontrol fungus may provide an additional or alternative form of inoculum for initiating disease in *Alisma* and related weeds.

Chlamydospores are readily produced on solid media and in some liquids. They produce multiple germ-tubes and can infect leaves. Because they produce conidia soon after germinating on the leaf surface, they may boost disease levels above that achieved with conidia alone. The greatest number of chlamydospores are produced on potato-based solid media. To be useful on a large scale, we must learn how to produce chlamydospores in liquid fermentation.

Chlamydospores of *R. alismatis* on the surface of a starfruit leaf.
**Influence of rice pesticides on invertebrate biodiversity (2404)**

**Project Leader:**
Dr Mark Stevens  
NSW Agriculture  
Yanco

This project is designed to provide information on the ecology and biology of chironomid midges other than *Chironomus tepperi* that inhabit rice fields during the crop establishment period. Whilst considerable attention has been devoted to *C. tepperi* because of its status as the primary pest species, virtually nothing is known about the other taxa, despite the fact that some of them are implicated as causing crop damage.

**Progress**

Over 1,200 chironomid larvae have been slide-mounted and approximately half of these have been identified, most to species level. A total of 16 species have been identified in Yanco rice fields in the first 40 days after crop flooding. Whilst *Chironomus tepperi* and *Procladius paludicola* are numerically dominant, substantial numbers of *Polypedilum nubifer* are also common in most seasons. Other genera identified in samples from the 1995/96 and 1997/98 seasons include *Kiefferulus, Cladopelma, Tanytarsus, Cladotanytarsus, Ablabesmyia*, and *Cryptochironomus*.

A fish food/yeast/algae diet has been successfully developed for rearing *Polypedilum nubifer* through from eggs to adulthood. Attention is now on getting the adults to lay eggs in the laboratory cultures.

**Sustainability of rice production systems (2405)**

**Project Leader:**
Dr Mark Stevens  
NSW Agriculture  
Yanco

This project encompasses two postgraduate research projects, a MSc(Med) project on mosquito ecology in NSW rice fields being undertaken part-time through the University of Sydney by Ms Liesl Schiller, and a BSc(Hons) project on the environmental toxicology of the herbicide clomazone, to be undertaken by Ms Ayesha Burdett on a full-time basis through the University of Melbourne, commencing July 1999.

**Progress**

The mosquito study, which is being co-supervised by Dr Stevens and Assoc. Prof. Richard Russell of ICPMR, Westmead Hospital, has now been running for approximately 12 months and one season’s sampling has been completed. Three conventional rice crops in the Leeton area were monitored at three week intervals throughout the 1998/99 rice season, using dipper counts to assess larval populations. Dipper calibrations were also conducted during the season, using enclosures containing known numbers of *Culex annulirostris* larvae. Over 95%
of the larvae collected have been identified. Results to hand indicate that the mosquito fauna in NSW rice fields is not very diverse, with only four species being identified; the majority of larvae collected were either *Culex annulirostris* or *Anopheles annulipes*. This contrasts with earlier published studies on Queensland rice fields where the fauna was much more diverse. In addition, Queensland fields tended to produce substantial numbers of mosquitoes throughout the entire cropping cycle; in our study, mosquito production remained very low until late January, before increasing substantially in the last two months before crop draining.

Dragonfly nymphs are important predators of ricefield mosquito larvae

**Biodiversity assessment of MIA ricefields using stable isotope analysis (2406)**

*Project Leader:*
*Dr Mark Stevens*
*NSW Agriculture*
*Yanco*

This project is being undertaken by Ms Andrea Wilson, PhD student at Charles Sturt University. The project’s aims are to document the diversity of floodwater fauna in commercial rice fields of the Murrumbidgee Irrigation Area, identify the major food resources being utilised within rice field ecosystems using stable isotope analysis and determine whether different farming practices influence biodiversity and food web structure.

**Progress**

Preliminary studies on sampling efficiency have been completed. In the 1998/99 season nine study sites (three aerial-sown conventional, three sod-sown conventional and three sod-sown organic) were monitored during the early, middle and late stages of the season. A total of 945 quantitative samples were taken, and invertebrates have been separated out from approximately 25% of these. Chemical use, temperature, plant biomass, pH, dissolved oxygen and conductivity were also monitored at each site. Major faunal groups for use in the isotope analyses have been identified and isotope analysis samples of major nutrient sources have been taken from the three different classes of study sites. These samples will be analysed in September 1999.
<table>
<thead>
<tr>
<th>Milestone</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Soil Chemical &amp; Physical Properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appointment of Post Doctoral Fellow</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of N soil test</td>
<td>X Commenced</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appointment of Technical Officer</td>
<td>X Modified</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil acidity problem definition</td>
<td>X Acid Soils Program</td>
<td>X ✓</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definition of soil property damages</td>
<td>X Commenced</td>
<td>X ✓</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Evaluation of aerial video as a tool</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Definition of management factors affecting nutrient recovery</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>PhD project – spatial analysis</td>
<td>X Commenced</td>
<td>X ✓</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2.2 Environmental Change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appoint Research Scientist</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Define flowering test for cold resistance</td>
<td>X Commenced</td>
<td>X ✓</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confirm tolerance under field conditions</td>
<td>X Commenced</td>
<td>X Continuing</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student projects</td>
<td>X One appointed</td>
<td>X ✓</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understanding cold and Nitrogen interaction</td>
<td>X Commenced</td>
<td>X ✓</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lipid metabolism</td>
<td>X Program modified</td>
<td>X Suspended – will recommence in Year 3 as modified project</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understanding cellular response to cold</td>
<td>X Commenced</td>
<td>X ✓</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application of cold studies</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Studies on climate change</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3 Mineral Nutrition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appointment of staff</td>
<td>X Commenced</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appointment of student</td>
<td>X Not achieved</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Review of factors affecting yield and quality</td>
<td>X Commenced</td>
<td>X ✓</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of techniques</td>
<td>X Commenced</td>
<td>X ✓</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assess mineral changes</td>
<td>X Commenced</td>
<td>X ✓</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assess impact of yield improvement and management changes on mineral/quality relationships in rice and its relatives</td>
<td>X</td>
<td>X ✓</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determine mechanisms influencing translocation of minerals to grain</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Milestone</td>
<td>Year 1</td>
<td>Year 2</td>
<td>Year 3</td>
<td>Year 4</td>
<td>Year 5</td>
<td>Year 6</td>
<td>Year 7</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Modify factors influencing quality in intensive ricegrowing</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4 Sustainable Crop Protection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appointment of PhD student</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appointment of Honour students</td>
<td>X Replaced by visiting scientist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology of Arrowhead and Water Plantain</td>
<td>X RIRDC projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Better understand biocontrol</td>
<td>X ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification of dominant bloodworm species</td>
<td>X Commenced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop lab techniques for at least 1 additional Chironomid</td>
<td>X Commenced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluate Bti* transgenic lines</td>
<td>Staff appointed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allelopathy</td>
<td>X With Program 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progress towards identification of allelochemicals</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved pathogenicity of R.alismatis to Alismataceous weeds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phenology and host specificity of bloodworm species defined</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration of chemical and biological management of weeds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determination of susceptibility of major cultivars to exotic pests and diseases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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