Fig. 3. Temperature profiles in experimental grain silo fitted with heated external wall.

Fig. 4. Principal elements of an open cycle, solar regenerated desiccant bed grain cooling system.

Fig. 5. Psychrometric chart showing the operation of the desiccant bed cooling system.

The underlying principles of operation of the stage-wise system can be understood from the psychrometric chart (Fig. 5). Cool ambient air with a high relative humidity, state 1, is compressed by the fan to state 2. It is this air that would normally be used for ventilating grain in ambient aeration systems, but because of its high enthalpy it has limited cooling capacity. In the desiccant bed cooling system the air is cooled from state 2 to state 3 in the first heat exchanger, HE1. The air on entering the first desiccant bed, DB1, leaves at state 4, whence it is cooled by the atmosphere to state 5. Now this represents a reduction in enthalpy compared with natural aeration systems, but a further reduction is obtained by passing the air through the second desiccant bed, DB2, bringing it to state 6, before finally cooling it to state 7. It is this air that is used to cool the grain. An experimental single cooling stage is shown in Fig. 6.

The system is still at the developmental stage. However, computer modelling and experimental results indicate that under tropical conditions the enthalpy of ambient air can be reduced by about 20 kJ/kg. This means that grain cooled with ambient air to 26°C could be cooled to less than 20°C with air leaving the desiccant bed system. To summarise then the solar regenerated open-cycle desiccant bed grain cooling system has the following attributes:

- It is very simple to construct from readily available materials and its fabrication requires only basic sheet metal working skills.
- It achieves a significant reduction in the heat content of ambient air, hence considerably lower grain temperatures can be achieved.
- Apart from a solenoid valve, no more moving parts are required than for a conventional aeration system.
- It may prove possible to use renewable desiccants, such as cereal grains themselves.
- It is planned to test the device in a tropical environment.

Sorption Studies

An essential component of a study of moisture migration in grain is a thorough knowledge of the...
thermodynamics of sorption. From the thermodynamics of equilibrium, it is possible to derive that the relative humidity, \( r \), of intergranular air is given by

\[
r = k\left(\frac{p_s}{h_v}\right)^{\frac{1}{h_v-1}}
\]

where \( p_s \) is the saturated vapour pressure of water, \( h_v/h_r \) is the ratio of the latent heats of bound and free water, and \( k \) is a constant. By fitting the above equation to empirical data it was found that \( (h_v/h_r-1) \) is a transcendental function of the grain moisture content. By this means an accurate isostere equation has been derived for barley, maize, rapeseed, rice, sorghum, soybeans, sunflower seeds, and wheat.

**Rapid Drying of Rice**

As part of a program of studies aimed at developing an integrated approach to the handling and storage of wet grains, the CSIRO Division of Chemical and Wood Technology is devising energy-efficient methods of grain drying. One promising method of rapidly drying paddy is by means of intermittent heating in a fluidised bed.

In this work, Calrose (medium grain) and Inga (long grain) rice of 11.7 and 11.3\% m.c. (wet basis) respectively, were heat treated in a small batch, fluidised-bed rig using ambient and air of 40°-80°C at 5°C increments and heating times of 5, 10, and 20 minutes. Also, freshly harvested Calrose and Inga of 20.3 and 21.8\% m.c. respectively, were dried in the same apparatus to approximately 14\% m.c., using ambient and air of 35°-80°C at 5°C increments for periods of between 11.5 and 29.1 minutes depending on temperature and variety. Germination and head rice yields were used as indexes of heat damage.

For the low moisture content rice, germination was adversely affected at temperatures greater than 70°C for Calrose and greater than 75°C for Inga. Head yield was adversely affected at temperatures greater than 60°C for both varieties. The effect of heating time was highly significant.

For the high moisture content rice, germination was adversely affected at temperatures greater than 60°C for both varieties. All heat treatments significantly affected the head yield which fell by 9-100\%, depending on the temperature. In both cases, Calrose was more susceptible to heat damage than Inga with regard to head yield.
Abstract

This project examines the effects on grain quality of storage under controlled atmospheres, particularly those with high contents of carbon dioxide. It also provides quality testing services for other projects in the ACIAR Grain Storage Research Program. Only preliminary results are available. These indicate that low oxygen atmospheres reduce loss of germinability in rice and sorghum and discoloration in rice. Carbon dioxide (60%) has the converse effect on rice.
Background

Summary

Large amounts of grain and similar foodstuffs in tropical countries are held in warehouses as stacks of bagged products. Preservation of these commodities is a difficult and expensive operation and losses have been high. Attention to the problem has been given a high priority by international agencies such as FAO and by the relevant authorities in the developing countries of Southeast Asia, particularly the Philippines.

Project 8314 is closely linked to Project 8307, which is concerned with developing the technology for storing grain under plastic covers. It also interfaces with other projects in the ACIAR Grain Storage Research Program the objective of which is to develop systems of safe storage for grain in the difficult storage environment of the humid tropics. Project 8307 addresses specifically the questions relating to the effects of storage on quality which must be answered if protection of foodstuffs by enclosing them in large plastic envelopes is to be recommended and brought into widespread use. These questions have been raised by the developing country institutions interested in developing the technique for local use and were given high priority for attention by participants in the 1983 Grains Post-Harvest Workshop of the ASEAN Crops Post-Harvest Programme. The Philippines has indicated a desire to take a lead in this research.

Project 8314 is designed to determine how oxygen and carbon dioxide tensions in the storage atmosphere interact with temperature and moisture and the effects these interactions have on the quality of the commodities in storage. This information will determine the conditions required for safe storage of the commodities and the modifications necessary to existing systems to achieve this. The data will also be used for developing models for heat and moisture balance that will enable extension of the technology into storage of commodities in bulk.

Differences in the retention of quality under different atmospheres may take many months to become apparent at the storage temperatures normally encountered in the tropics. Some form of accelerated storage test is thus highly desirable to quantify, in a reasonable time, the effects of controlled atmospheres on the quality of grain. A systematic study of the combined effects of atmospheric composition, temperature, and relative humidity on the quality of various grains during storage is in progress. The temperatures used in the study are above the normal range encountered in storage in the humid tropics. It is assumed that the changes observed will parallel those that occur more slowly under normal storage conditions. This assumption has yet to be tested thoroughly.

Assessments of quality are being carried out in Australia and the Philippines, in the latter case by the National Post-Harvest Institute for Research and Extension (NAPHIRE), which provides the research support for the National Food Authority (NFA). NFA is responsible for the procurement, safe storage, and distribution of foodstuffs throughout the country. The quality assessment team will also service other ACIAR grain storage projects in the Philippines and provides a model for the type of facility which could support the ongoing research programs in that country.

Only preliminary results are available. They indicate that low oxygen atmospheres reduce loss of germinability in rice and sorghum and discoloration in rice. Carbon dioxide (60%) has the converse effect on rice.

Expected Benefits

1. Development of a quantitative understanding of the interaction of atmosphere composition, temperature, and water activity on the quality of commodities in storage. This information is necessary for efficient and safe utilisation of the storage technology being developed in ACIAR Project 8307 on Long Term Storage of Grain under Plastic Covers, which is being conducted by the CSIRO Division of Entomology.

2. Acquisition of basic data for integration into models of heat and moisture environments in storages (ACIAR Project 8310 on Moisture Movement in Grain) to allow further development of the technology.

3. The activities in the Philippines will provide a model for a quality testing facility to support continuing research programs in that country.

Project Objectives and Operational Schedule

This project is designed primarily to provide basic support to ACIAR Project 8307 on Long Term Storage of Grain under Plastic Covers and to provide data and a grain quality testing facility for other projects in the ACIAR Grain Storage Research Program.

Accelerated storage tests are being used to evaluate various combinations of commodity and storage atmosphere to enable models to be devel-
oped of the effects of storage factors on grain quality. These models will in turn be incorporated into more comprehensive models on heat and moisture balance in storage systems to enable national design of storage containers and management procedures.

The specific objectives of the project include the following:

1. Determination of the influence of oxygen and carbon dioxide tension in the storage atmosphere, in combination with temperature and water activity, on the viability and end-use parameters of stored grains, spices, and pulses.

2. Provision of these data in a form which can be integrated in an overall model of heat and moisture balance in storage systems.

3. Examination of the relationship between water production and various storage gases (including phosphine) during storage in closed systems.

4. Provision of grain quality testing facilities for other projects in the ACIAR Grain Storage Research Program.

All storage experiments are being carried out in Australia. Quality evaluations are being made in Australia and the Philippines.

The commodities concerned are 11 grains, 3 spices, 2 pulses, and coffee. Samples of these of known moisture provenance are being subjected to controlled atmospheres at elevated temperatures which simulate longer term storage at the particular moisture level. The experimental conditions are as follows:

Temperatures: 30, 35, 47, and 60°C
Humidities: 40, 60, 80, and perhaps 90%
Atmospheres: 0.2% oxygen, balance nitrogen
2% oxygen, balance nitrogen
21% oxygen, balance nitrogen (i.e. air)
100% oxygen
7.5% carbon dioxide, 8.4% oxygen, balance nitrogen
15% carbon dioxide, 8.4% oxygen, balance nitrogen
30% carbon dioxide, 8.4% oxygen, balance nitrogen
60% carbon dioxide, 8.4% oxygen, balance nitrogen

The maximum proposed range of experiments is given in an accompanying table.

After storage for the maximum practicable periods, commodities will be tested in collaboration with the research team in the Philippines for quality characteristics related to the end-use of each commodity. These characteristics, which include quality standards currently used by the Philippine National Food Authority, are germination, colour, milling yield, moisture content, cooking, and microbial activity.

Eight of the storage experiments have been completed or are under way. These are indicated in the accompanying table. Progress according to the agreed research schedule is illustrated in the project flow diagram. The schedule was interrupted because of the need to calculate equilibrium moisture contents at the proposed moisture conditions but has now been resumed.

Further experiments will be carried out over a six-month period to determine the effect of carbon dioxide and other storage gases on water activity in closed systems. Water output of grains will be measured in the presence of various levels of carbon dioxide at 14% m.c. and 30°C using the following atmospheres: air; 10, 30, and 60% carbon dioxide in air; 10% carbon dioxide + 10% O₂, balance nitrogen; and one reference concentration of phosphine, 0.5 g PH₃/m³ in air. Plate counts of fungi will be run and water output of unsterilised and surface-sterilised samples will be compared. These studies will be undertaken at the CSIRO Division of Entomology in collaboration with ACIAR Project 8307.

It is estimated that three years will be required to complete the series of experiments previously outlined.

**Organisation and Staff**

The Record of Understanding between ACIAR and CSIRO was signed on 11 July 1984.

Dr P. Gras and Dr I. Batey were nominated by CSIRO as joint Research Leaders. The CSIRO Wheat Research Unit also nominated Mr M. Bason, an Experimental Scientist, to be responsible for conduct of experimental work in Australia and Miss A. Morris, Technical Assistant, to support these activities.

### Grain Storage Research Program

**Project 8314 Staff**

**CSIRO Wheat Research Unit**
Mr M. Bason, Experimental Scientist
Dr I. Batey Research Leaders
Dr P. Gras
Miss A. Morris, Technical Assistant

**NAPHIRE**
Mr C. Mordido, Jr., Team Leader
Research schedule — Project 8314 (shaded area indicates work completed)
Proposed grains and conditions for controlled atmosphere storage experiments. Proposed experiments are indicated by a cross; completed experiments are indicated by a value denoting the moisture content (wt basis) of the grain.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>30</th>
<th>35</th>
<th>47</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative humidity (%)</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Rice Paddy Calrose</td>
<td>X</td>
<td>X</td>
<td>14.0</td>
<td>X</td>
</tr>
<tr>
<td>Milled Calrose</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Milled Inga</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Maize Manning White</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hickory King</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Manning Pria 'Cornflakes #1'</td>
<td>X</td>
<td>X</td>
<td></td>
<td>14.9</td>
</tr>
<tr>
<td>'Cornflakes #2'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Golden Superb</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Sorghum</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Soybean</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Mung Bean</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Coffee</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Spices Chilli</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Cardamom</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Cloves</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

The Memorandum of Agreement between ACIAR and the Philippine Council for Agriculture and Resources Research and Development for collaborative activities with NAPHIRE was also finalised on 14 July 1984. NAPHIRE nominated Mr Cris Mordido Jr. as Team Leader in the Philippines. Mr Mordido is also involved in Project 8311.

Research Activities in Australia and Southeast Asia

The Australian Research Leader, Dr P. Gras, visited Malaysia from 19–25 August 1984 for joint discussions with Project 8309 personnel on quality assessment of rice in their field trials. While in Malaysia he attended the ASEAN Crops Post Harvest Programme 1984 Grains Post-Harvest Workshop, which was held in Kuala Lumpur from 21–24 August 1984. He then visited the Philippines from 25 August to 3 September for discussions on implementation of Project 8314 in NAPHIRE.

Mr M. Bason attended the ACIAR/NAPHIRE/AFHB Seminar on Pesticides and Humid Tropical Grain Storage Systems held in Manila from 27–30 May 1985. He stayed on for discussions with NAPHIRE concerning project activities.

The Philippine Team Leader, Mr Cris Mordido Jr., visited Australia from 11–21 April 1985. As well as obtaining experience in experimental procedures at the CSIRO Wheat Research Unit in Sydney, he inspected facilities and had discussions with ACIAR project personnel at Ricegrowers’ Cooperative Ltd at Griffith, the Department of Agriculture’s Rice Research Institute at Yanco, and the CSIRO Stored Grain Research Laboratory in Canberra.

Grain Moisture Content Determination

Preliminary storage experiments have revealed the need to set the grain moisture content at its equilibrium for the proposed storage conditions before storing it at those conditions. As a result, the equilibrium moisture contents of the various grains at the proposed experimental conditions are currently being determined. Before grain is exposed to the experimental storage conditions, it is conditioned to the appropriate moisture content, as determined from these experiments.
Effect of Controlled Atmospheres on Quality

Experiments completed to date have concerned paddy, maize, and sorghum. Germination data have been obtained from six of these experiments. Although the results are as yet far from conclusive, trends so far observed in paddy are similar to results obtained for wheat. That is, storage life is increased with decreased oxygen levels, and carbon dioxide (60%) markedly reduces germinability for high moisture grain. The same result with carbon dioxide has been observed with sorghum, but not yet noticeably with maize. Low oxygen atmospheres (2%) are also correlating with increased storage life in sorghum and maize.

Preliminary results on discoloration of milled rice under controlled atmospheres indicate that greying and yellowing are a function of storage period and storage atmosphere. Storage in low oxygen atmospheres slightly reduced the rate of development of discoloration relative to that found in air, whereas storage in carbon dioxide significantly increased the overall yellowness and decreased the lightness of rice stored at 47°C and 80% RH, and also significantly increased the yellowness of rice stored at 60°C and 60% RH. This is illustrated in an accompanying diagram. The yellowing referred to here was an equal discoloration of all kernels and, because it occurred at high temperatures, it is unlikely to be due to mould growth. The results suggest that carbon dioxide may exacerbate the development of yellowing of rice in storage.

![Diagram](image)

**Relationship between yellowing in polished Calrose rice and the composition of the storage atmosphere at 47°C and 80% RH.**
Abstract

The basic objective of the project is to develop a model of the Malaysian rice economy which integrates all diverse components of the paddy and rice handling industry. The model will be evaluated empirically using observed data from the Tanjung Kerang area in North-West Selangor. The extent to which the model is generally applicable to other rice producing regions in Malaysia will be assessed. The model will be used to analyse alternative paddy transport and handling activities as well as paddy grading systems so as to determine the most socially efficient locational pattern, number, and size of paddy handling and rice distribution facilities.
Background

MALAYSIA currently produces about 75% of its rice needs, and could move closer to self-sufficiency if avoidable postharvest losses were reduced. Malaysian institutions involved in the handling and milling of paddy and the distribution of rice believe that the introduction of innovations in handling paddy, coupled with an improved grading system, will reduce losses significantly. The innovations envisaged include the use of bulk-handling equipment, more efficient drying equipment, and increased milling capacity to reduce delays before milling. The Malaysian authorities, in planning investments in handling facilities, are also confronted with the complex and recurring problem of determining the most efficient locational pattern, number, and size of procurement centres, drying plants, and rice mills. Against this background, the Malaysian Government, through its Economic Planning Unit, has requested assistance from and collaboration with Australian institutions involved in researching similar problems.

The request for participation by Australia in a study of the transition from bag to bulk handling in Malaysia originated from the 1979 ADAB Research for Development Seminar on grain storage research. The Director of Research of Lembaga Padi dan Beras Negara (LPN) identified the problems associated with bulk handling as an area where Australian expertise would be useful. At a meeting convened by the Malaysian Agricultural Research and Development Institute (MARDI) in April 1983, to discuss Malaysian participation in the ACIAR Grain Storage Research Program, MARDI and LPN unilaterally made reference to the high priority given to the development of a bulk-handling capacity in Malaysia and requested ACIAR to give consideration to cooperative work in developing an appropriate bulk-handling system for Malaysia. A proposal for handling wet paddy in bulk was tendered for ACIAR's consideration. In essence, the proposal involved a systems analysis of grain handling in Malaysia, from harvesting of paddy through to processing and distribution of rice. The discussion confirmed this intent. The matter of Australian involvement was raised again the next day by the Deputy Director-General of LPN at a meeting of the Programme Steering Committee of the ASEAN Crops Post-Harvest Programme in Singapore and soon afterwards by the Director-General during a workshop on Bulk Handling of Paddy in Malaysia in June 1983.

Clearly, a study of the economics of postharvest handling of paddy and rice in Malaysia has been accorded a very high priority and the desirability of Australian participation has been stressed by all the Malaysian authorities concerned.

Expected Benefits

The project will use current modelling technology to indicate the extent to which postharvest losses in rice can be reduced by the adoption of more efficient handling systems. The models developed will also be used to evaluate the additional cost savings in paddy transport, drying, storage, and processing.

Quantification of the potential net benefits from changing to an improved bulk-handling system is difficult. The main benefits will presumably be in the reduction in postharvest losses of paddy. In the Selangor project area alone, it is estimated that the gross value of annual paddy production can be increased by around 10% if postharvest losses of paddy could be reduced by 50%, from around 18% to 9%. This would mean an extra $A3-4 million of extra revenue to the region, which also represents the potential dividend from an investment in bulk-handling facilities.

In addition to the potential benefits from reduced paddy losses, significant benefits are likely to be realised from rationalisation of existing grain handling facilities and transport networks. Studies elsewhere suggest that reductions of 20–30% in present marketing costs can be achieved by handling paddy and rice more efficiently. In the Selangor region this would mean an extra $A2-3 million could be saved annually, simply by implementing a more efficient handling and transportation system.

If the benefits estimated for the Selangor region were extrapolated to include the whole Malaysian Peninsula this would mean an annual saving to the country’s rice economy of between $A90-110 million, which is a significant return on investment in bulk-handling facilities and research costs.

A further benefit will be an enhancement of the capacity of the Malaysian institutions to undertake applied economic research in transport, processing, distribution systems, and cost and quality analyses.

Project Objectives and Operational Schedule

The basic objective of the project is to develop a model of the Malaysian rice economy which inte-
grates all diverse components of the paddy and rice handling industry. The model will be evaluated empirically using observed data from the Tanjung Kerang area in North-West Selangor. The extent to which the model is generally applicable to other rice producing regions in Malaysia will be assessed. The model will be used to analyse alternative paddy transport and handling activities as well as paddy grading systems so as to determine the most socially efficient locational pattern, number, and size of paddy handling and rice distribution facilities.

Sensitivity analyses will also be conducted of the effect of nominated changes in appropriate decision variables, such as handling and transportation costs, timeliness of the delivery system, and capacities of the handling and distribution system, for a range of rice qualities and standards. Issues relating to the efficiency and distribution effects of changes in paddy pricing structures on the optimal solutions will also be analysed.

The core component of the project is the development and specification of a mathematical programming model. This work will be carried out by the South Australian Department of Agriculture in Adelaide under the general supervision of the Australian Project Leader.

The Malaysian research team will be responsible for assembly of the database and for placing the data in a form suitable for subsequent processing in the model.

There will be close collaboration between other institutions engaged in the ACIAR Grain Storage Research Program. In particular, the research group in Ricegrowers' Co-operative Limited (RCL), which is already undertaking Project 8308 on grain drying in Malaysia, will provide advice on the technical feasibility of improved bulk handling, drying, and milling equipment. Similarly, the Malaysian research team will be a consortium of Universiti Pertanian Malaysia (UPM) and MARDI as the primary economic and technical research institutions concerned with the rice industry in Malaysia, in collaboration with LPN.

The proposed schedule of major events is shown in the project flow diagram. Key elements are the development of the model in Australia and the field survey work in Malaysia needed to obtain data for input into the model.

Organisation and Staff

A Project Formulation Meeting was held at Ricegrowers' Co-operative Ltd in Leeton on Friday 13 July 1984. Its objectives were:

1. to discuss the scope and objectives of the proposed project;
2. to determine an operational framework for the activities, including delegation of responsibility; and
3. to draw up a definitive schedule of operations.

The meeting was attended by:

- Dr J.G. Ryan, Deputy Director, ACIAR (Chairman);
- Dr Ismail Shamsudin, Director-General, LPN;
- Mr Zainuddin Dato Awang Ngah, Deputy Secretary-General, Ministry of Public Enterprises, Malaysia;
- Mr Ahmad Ilham Abdul Samada, State Director, Kedah and Perlis, LPN;
- Mr Loo Kau Fa, Chief Engineer, LPN;
- Mr H. Baird, Deputy General Manager, RCL;
- Mr J. Kennedy, Export Manager, RCL;
- Mr S. Dunn, Operations Manager, RCL;
- Mr L. Bramall, Technical Manager, RCL (Project 8308B);
- Mr B. Bourne, Engineering Manager, RCL;
- Mr P. Martin, Research and Development Manager, RCL;
- Mr G. Pym, Storage Research Manager, RCL (Project 8308B);
- Mr P.C. Annis, CSIRO Division of Entomology (Project 8307A, B);
- Dr M. Bengston, Deputy Director, Entomology Branch, Queensland Department of Primary Industries (Project 8309);
- Dr J.H. Johnston, Senior Economist, N.S.W. Department of Agriculture;
- Dr G.J. Ryland, Chief Agricultural Economist, S.A. Department of Agriculture;
- Mr T. Adamczak, Professional Officer, University of N.S.W. (Project 8308A);
- Dr B.R. Champ, Research Program Coordinator, ACIAR.

Before discussion on the detailed arrangements for the proposed project, the following position and background papers were presented to the meeting:

- 'The ACIAR Grain Storage Research Program: perspectives and current activities', by Dr B.R. Champ;
- 'Economic research on grain-handling, storage, and marketing in Australia', by Dr J.H. Johnston;
- 'Development of a bulk-handling system for paddy and rice in Australia', by Mr L. Bramall;
- 'Current status of harvesting, handling, transport, and marketing of paddy and rice in Malaysia', by Dr Ismail Shamsudin; and
- 'Changeover options for developing countries: some appropriate models', by Mr J. Kennedy.

An approach was made after the meeting to the South Australian Department of Agriculture to draw up a firm proposal on 'Bulk Handling of
ACIAR GRAIN STORAGE RESEARCH PROGRAM

Project 8344 - Bulk handling of Paddy and Rice in Malaysia: an Economic Analysis

ACIAR GRAIN STORAGE RESEARCH PROGRAM
Project 8344 - Bulk handling of Paddy and Rice in Malaysia: an Economic Analysis

Research schedule — Project 8344
The formulation of Project 8344, as with all ACIAR projects, involved many discussions between research and operational groups in Australia and participating countries.

Paddy and Rice in Malaysia: an Economic Analysis.

Further discussions on the draft proposal were held in Malaysia on 19–20 August 1984 in conjunction with attendance at the ASEAN Crops Post-Harvest Programme 1984 Grains Post-Harvest Workshop in Kuala Lumpur. The first meeting was held in Alor Setar on 19 August. LPN was represented by Dr Ismail Shamsudin, Mr Loo Kau Fa, and Mr Teoh Inn Chek, Senior Engineer from LPN Head Office and Mr Ahmad Samad and his Deputy Director of the Kedah and Perlis State Office, Mr Mohd Dushilah Alang Mohd. ACIAR representatives were Dr G. Ryland, Dr J. Johnston, Dr R. Driscoll (Project 8308A), Mr L. Bramall (Project 8308B), Mr G. Pym (Project 8308B), Mr E. Highley (Project 8312), and the Program Coordinator. Inspections were then made of field activities in the Muda II Farm Development Project at Tambun Tulang. The following day, the party inspected the North West Selangor Development Project at Tajung Kerang which had been nominated by LPN as the project study area. A final meeting between representatives of ACIAR, LPN, and MARDI, was held on 22 August in Kuala Lumpur to discuss project implementation.

The Record of Understanding between ACIAR and the South Australian Department of Agriculture was signed on 26 June 1985 with a scheduled start on 1 July 1985.

Dr G.J. Ryland, Chief Agricultural Economist, has been nominated by the South Australian Department of Agriculture as Research Leader. A Senior Research Economist, Mr B. Hansen, has been appointed to work with Dr Ryland. They will be supported by Mr Omar Bin Yob, a Malaysian Research Economist from LPN who will be based in Australia, with provision to undertake postgraduate training within the project. Project administration will be the responsibility of Dr G. Simpson and Mr J. Fargher of SAGRIC International. These personnel, together with contract research consultants engaged to provide specialist advice on specific aspects of the project, comprise the Australian research team.

The Malaysian research team will operate from UPM, in close collaboration with MARDI and LPN. The Agreement for these operations was finalised with the Economic Planning Unit of the Malaysian Government on 27 July 1985 for a formal start on 1 July 1985, as with activities in Australia. Dr Mohd Ghazali Mohayidin and Dr Chew Tek Ann
have been nominated by UPM as joint research leaders in Malaysia. They will be supported at UPM by two senior research economists, Dr Fatimah Mohd. Anshad (Cost and Quality Analysis) and Dr Roslan Abd. Ghaffar (Systems Analysis), three research assistants, Mr Muzafar, Mr Azman, and Miss Hafrizah, and two graduate assistants funded by IDRC, Mr Salleh Yahya and Mr Siow Keat Foo. MARDI collaborators will be Dr Othman, agronomist, and two economists, Mr Shaaban and Mr Syed. Mr Loo Kau Fa, Chief Engineer, has been nominated as the prime contact in LPN.

During the period 1 January to 30 June 1985, the management structures were developed and all other arrangements for project activities were finalised for a start on 1 July as scheduled. Dr Ryland conducted a seminar broadly outlining the project to local participants at UPM on 3 May 1985.

Grain Storage Research Program

Project 8344 Staff

*South Australian Department of Agriculture*
Dr G.J. Ryland, Project Director
Mr B. Hansen, Senior Research Economist
Dr G. Simpson, Project Administration
Mr J. Fargher

*Universiti Pertanian Malaysia*
Dr Mohd Ghazali Mohayidin, Research Leaders
Dr Chew Tek Ann
Dr Fatimah Mohd. Anshad, Senior Research Economist (Cost and Quality Analysis)
Dr Roslan Abd. Ghaffar, Senior Research Economist (Systems Analysis)

Mr Muzafar Shah Habibullah, Research Assistant
Mr Azman Bin Hassan, Research Assistant
Miss Hafrizah, Research Assistant
Mr Salleh Yahya, Graduate Assistant (funded by IDRC)
Mr Siow Keat Foo, Graduate Assistant (funded by IDRC)

*Malaysian Agricultural Research and Development Institute*
Dr Othman, Agronomist
Mr Shaaban, Economist
Mr Syed, Economist

*Lembaga Padi dan Beras Negara*
Mr Omar Bin Yob, Economist (based at S.A. Department of Agriculture)
Mr Loo Kau Fa, Chief Engineer
Project 8312

Program Development and Coordination

Commissioned organisation — CSIRO Division of Entomology

Introduction
Organisation and Staff
Internal Workshops
Research Information Network
  ACIAR Grain Storage Newsletter
  Databases and Information Retrieval Services
Collaborative Activities
  Participation in GASGA
  ASEAN Food Handling Sub-Committee, Grains Working Group
  Attendance at International Conferences and Workshops
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Introduction

The formulation and implementation of the ACIAR Grain Storage Research Program has been achieved by contracting Project 8312 with the CSIRO Division of Entomology. The project provides an operational framework for the development and coordination of ACIAR's activities in the grain storage area. This is seen as an essential component of the program in maximising its effectiveness both in terms of use of resources and research output. Project 8312 has an initial duration of three years.

The Grain Storage Research Information Network and associated activities have materially increased the availability of information on existing technology to relevant organisations in Southeast Asia, expedited conduct of the ACIAR program, increased the impact of the program in overcoming storage problems in the area, and facilitated cooperative activities both within the ACIAR program and with other agencies concerned with post harvest research and technology.

The objectives of Project 8312 are:

1. To develop and coordinate a program of research to ensure grain can be stored safely.
2. To develop a grain storage research information network with participation by all relevant organisations in Australia and overseas.
3. To publish a regular newsletter to disseminate information.
4. To provide a literature search and information retrieval facility.
5. To conduct workshops as appropriate in cooperation with local organisations and publish proceedings of these workshops.
6. To produce, as required, publications relevant to grain storage in developing countries.

Organisation and Staff

Dr B.R. Champ was seconded from the Division of Entomology to act as Research Program Coordinator for an initial period of three years from 7 April 1983.

Mr E. Highley, formerly Scientific Liaison Officer in the Division of Entomology, was appointed Editor of the ACIAR Grain Storage Newsletter on 13 March 1983. He has spent approximately five weeks per year on project activities, editing and producing the biannual newsletter and other project publications. On his resignation from the Division on 28 February 1985, he was retained by the Division as a communications consultant to continue his association with the project. He has also been contracted directly by ACIAR to assist in the organisation and production of the proceedings of the ACIAR/NAPHIRE/AFHB Seminar on Pesticides and Humid Tropical Grain Storage Systems. As well as attending all internal workshops of program personnel, during 1984 Mr Highley visited the Philippines (15–18 August), Malaysia (18–25 August), and Thailand (25–28 August) to gather material for the newsletter and to promote the research information network in Southeast Asia. As part of this trip, he participated in the ASEN Crops Post-Harvest Programme 1984 Grains Post-Harvest Workshop, which was held in Kuala Lumpur from 21–24 August, and presented a paper on 'Moving towards pesticide free storage of grain in Australia', which he co-authored with Dr D.E. Evans of CSIRO. He also attended the ACIAR/NAPHIRE/AFHB pesticides seminar which was held in Manila from 27–30 May 1985.

Mrs R. Goodwin, Grain Storage Librarian in the Division of Entomology, spends 10 hours per week on ACIAR project activities, in particular providing the program's literature search and information retrieval facility.

Mrs J. Olditch provides part-time secretarial and administrative support to the program. She replaced Mrs L. White who left the Division in January 1985.

Mr D. Rofe was appointed as Projects Officer on 4 September 1984 to provide administrative assistance to all ACIAR projects in the Division of Entomology, including those in the Grain Storage Research Program. He spends half his working time on ACIAR-related activities, including:

- the preparation of annual estimates of expenditure for projects, including calculation of advance payments and acquittals of money expended;
- the monitoring of expenditure in each project;
- assistance with the development of systems and computer programs to facilitate the provision of estimates and financial control information;
- assistance with the preparation of new proposals;
- assistance with the preparation and coordination of progress reports.

The Research Program Coordinator made the following overseas visits to facilitate conduct of activities in the program in Southeast Asia.

Malaysia and Philippines — 17 August to 1 September 1984
Philippines, Thailand, and Malaysia — 14–20 October 1984
Malaysia, Singapore, and Philippines — 7–12 January 1985
Philippines — 25 March–1 April 1985
Singapore and Indonesia — 21–30 April 1985
Philippines — 25 May–1 June 1985

In addition, periodic visits have been made to the contracting organisations in Australia.

**Internal Workshops**

Workshops attended by project personnel are held twice a year, hosted in turn by each of the project groups in Australia. The general objectives of these workshops are:

1. To familiarise Australian participants in the ACIAR Grain Storage Program with the full extent of current activities in the program.
2. To ensure maximum integration of project activities in Australia, including programming of interaction between projects, collaboration in necessary areas of common activity, and provision of facilities to other projects.
3. To discuss full exploitation of overseas resources for project activity, including cooperation between projects in the same area.
4. To present reports of activities for the previous half year and to discuss in detail the current status of each project and relevant research topics.
5. To discuss other matters that may be relevant to the program.
6. To inspect relevant research activity within the host organisation.

Following a decision at the second workshop to expand the meeting at which annual reports are discussed to provide for attendance by all professional staff, the third workshop was held at the Queensland Department of Primary Industries (Project 8309) on 31 July and 1 August 1984. The 27 participants were welcomed by Mr G.S. Purss, the Director of the Division of Plant Industry. After presentation of progress reports by the various project leaders, and discussion on a further 21 topics nominated by project personnel for inclusion in the agenda, the participants inspected work in progress, both in Project 8309 and elsewhere in the Entomology Branch.

The fourth workshop, scheduled for the CSIRO Wheat Research Unit in Sydney (Project 8344), was held over from the first half of 1985 until 25 July 1985 as the earliest date at which all project leaders could attend.

### Research Information Network

A research information network built around specialist library and publications services is an integral part of the grain storage program. It serves primarily to strengthen contacts between the diverse projects and research groups spread through the four countries currently involved in the program, and between the program and other post-harvest groups. The network's functions are:

- to disseminate project and project-related information between program participants in ASEAN and Australia;
- to provide specialist information retrieval services to program participants;
- to maintain contact and foster collaboration with other grain storage research and development groups in the region and elsewhere;
- to respond to requests for information on program activities from other bodies; and
- to produce publications aimed at improving grain storage technology.

### ACIAR Grain Storage Newsletter

A key element in the research information network is the **ACIAR Grain Storage Newsletter** published twice a year. The newsletter contains details of project activities, of seminars and workshops held or planned, of new publications and information retrieval activities, and of the work of other groups tackling postharvest problems.

The newsletter also contains articles on topics likely to be of general interest to a wide cross section of its readers in various countries. So far, these more general accounts have dealt with the rice industry in Australia, the ASEAN Crops Post-Harvest Programme, NAPHIRE, the ASEAN Food Handling Bureau, MARDI, CSIRO, thermal disinfection of stored grain, and pesticide residues. Coverage of the last of these topics is seen as a major project. Mr Jack Snelson, who recently retired from the position of Pesticides Coordinator in the Australian Department of Primary Industry, has produced a comprehensive, 60 000-word account covering all aspects of the regulation of pesticide residues in stored grain. This is being published in three parts, arranged around the Seminar on Pesticides and Humid Tropical Grain Storage Systems held in Manila in May 1985. The first, on the significance and safety of pesticide residues, appeared in the second issue of the newsletter in December 1984. The second and third parts, dealing with maximum residue limits and with efforts to achieve
international harmonisation of regulations covering pesticide residues, will be published in newsletters 3 and 4.

Some 650 copies of each issue of the ACIAR Grain Storage Newsletter are now distributed via an ever-growing mailing list.

**Databases and Information Retrieval Services**

Project activities under this banner promote the spread of information on stored products by supplying bibliographic references and publications to participants in the program in cooperation with other specialist libraries and by searching appropriate databases.

There was a substantial increase in demand for the library and information services during the year. Following extensive coverage of these services in the newsletter, 27 specialist searches were performed, almost half of them requested by members of the various country research teams. There was
also an increase in demand for copies of earlier searches, particularly from overseas workers. The topics of all searches made are listed in the newsletter. The following searches were carried out during the year.

- Drying of paddy
- Velocity distribution in packed beds of porous media
- Destruction of insects, mites, and microorganisms by microwaves
- Modelling of insecticide resistance
- Graetz problem in fluid mechanics of porous media
- Postharvest diseases of garlic
- Heat produced by respiration of damp bulk grain
- Ambient air drying of grain in high-humidity tropical conditions
- Snails as hosts for human and animal diseases
- Resistance of *Rhyzopertha dominica* to insecticides
- Statistical programs for CP/M microcomputer operating system
- Storage of bagged grains and legumes
- Insecticidal treatment and fumigation of bagged grains and legumes
- Uneven application of insecticides to stored grains
- Rice husks as fuel
- Irradiation of citrus fruits
- Residues of ethylene dibromide in citrus fruits
- Scale insects
- Scanning optical microscopes
- Ecology of stored products insects

There was also a substantial increase in the number of requests for publications, to well over 300. Most of the requests from overseas were for material produced by ACIAR and CSIRO.

An important element of the program's library resources is its possession of the only copy of the Stored Products Reference Index managed by the United Kingdom Ministry of Agriculture, Fisheries and Food. An exciting development during the year has been the progress made towards computerisation of the Index. Trials have been performed on a subset of the database using the STATUS retrieval language running on MAFF Prime computers. The research information network is liaising with the MAFF library to ensure that program participants gain the earliest possible access to the machine-readable form of the database.

**Collaborative Activities**

**Participation in GASGA**

ACIAR is the nominated Australian participant in the Group for Assistance on Systems relating to Grain After-harvest (GASGA). The Annual Executive Meeting, scheduled for England in 1985, commenced on 1 July.

**Attendance at International Conferences and Workshops**

A CSIRO/Australian Grain Institute Seminar and Workshop on Aeration System Design was held in Melbourne on 10–11 July 1984 and was attended by all personnel from Project 8310 as well as Mr T. Adamczak (Project 8308A), Mr J. Darby and Mr G. Pym (Project 8308A), Mr Loo Kau Fa (Project 8308), Dr Ismail Shamsuddin (LPN), and the Program Coordinator.

The ASEAN Crops Post-Harvest Programme 1984 Grains Post-Harvest Workshop, held from 21–24 August in Kuala Lumpur, Malaysia, was...
attended by a large contingent of ACIAR personnel who had arranged their scheduled project travel to coincide with the workshop. Those attending were Mr Ahmad Robin Wahab (Project 8307), Mr Chuwit Sukprakarn (Project 8307), Mrs G. Sabio (Project 8307), Mr J. van S. Graver (Projects 8307A,B), Mr Loo Kau Fa (Project 8308), Dr Ratana Putranon (Project 8308), Mr Justin Tumambing (Project 8308), Dr R. Driscoll (Project 8308A), Mr L. Bramall (Project 8308B), Mr G. Pym (Project 8308B), Mr A. Rahim Muda (Project 8309), Mrs P. Sayaboc (Project 8309), Dr M. Bengston (Project 8309), Dr P.R. Samson (Project 8309), Dr P. Gras (Project 8314), Dr G. Ryland (Project 8344), Dr J. Johnston (Project 8344), Mr E. Highley (Project 8312), and the Program Coordinator. Mr Highley presented a paper on 'Moving towards pesticide free storage of grain in Australia', which he co-authored with Dr D.E. Evans of CSIRO.

Dr Somchart Soponronnarit (Project 8308) attended a Seminar on Technology for Rural Development held at Khonkaen University in Thailand on 16-17 February 1985 and presented a paper entitled 'A feasibility study of in-store paddy drying', by S. Soponronnarit, C. Karnjanaboon, and R. Chirarattananon.

Dr G.R. Thorpe (Project 8310) was sponsored by the Commonwealth Science Council to attend the International Conference on Research and Development of Renewable Energy Technologies in Africa, which was held in Reduit, Mauritius, from 25 March-1 April 1985. He chaired a technical session on Energy Utilisation Technology: Crop Drying Commodities and presented a paper on 'Experiments on an open-cycle solar regenerated desiccant bed grain cooling system'. He also visited FAO, Rome, for discussions on a proposed FAO publication on 'Modified environments in agricultural buildings for developing countries'.

Other Aspects of Collaboration

ACIAR was represented by the Program Coordinator as an observer at the 2nd Meeting of the Programme Steering Committee of the ASEAN Crops Post-Harvest Programme in Manila on 10-11 January 1985. He also participated in the Donor-ASEAN Consultation Meeting of the Programme which was held in Singapore from 25-27 April 1985.

Dr R.H. Driscoll (Project 8308A) visited Indonesia, Malaysia, Thailand, and Singapore in July 1984 and delivered a lecture on rice-drying technology at the Universitat Sumatera Utara, in Medan, Indonesia.

Mr T.F. Ghaly (Project 8310) visited Egypt in February-March 1985 under the UNDP Transfer of Know-how Through Expatriate Nationals Project. Whilst in Egypt, Mr Ghaly made a study of factors affecting the loss of rice quality during storage. The Egyptian Government plans to implement some of his key findings.

Mr J.W. Sutherland (Project 8310) was a leader of a course on postharvest technology run at the University of Brawijaya, Indonesia during March 1985. This work was sponsored by the International Development Program of Australian Universities and Colleges.

A delegation from Malaysia visited Australia in July 1984 to attend a Project Formulation Meeting concerned with a feasibility study of bulk handling of paddy and rice in Malaysia. The delegates were Dr Ismail Shamsudin, Director-General, National Paddy and Rice Authority of Malaysia (LPN), Mr Zainuddin Dato Awang Ngah, Deputy Secretary-General, Ministry of Public Enterprises, Mr Ahmad Ilham Abdul Samad, State Director of LPN for Kedah-Perlis, and Mr Loo Kau Fa, Director of Engineering, LPN. They first attended a CSIRO/Australian Grain Institute Seminar and Workshop on Aeration System Design, which was held in Melbourne on 10-11 July 1984. En route to the Project Formulation Meeting, which was held at the Ricegrowers' Co-operative in Leeton on Friday 13 July, the party inspected the Grain Elevators working Group and attended the 15th Meeting of the Group in Bangkok from 16-18 October 1984, and the 16th Meeting in Manila from 26-27 March 1985. The latter meeting was followed by a field trip to Cotabato and the National Food Authority integrated grains complex at Tacurong in central Mindanao.
Board of Victoria’s Dunolly wheat sub-terminal with its pilot fluidised-bed heat disinestation plant, and the Rice Marketing Board’s computerised in-store rice drying complex at Deniliquin. After the meeting, the party inspected rice storage and processing facilities in the Leeton–Griffith area on 14 July, and the N.S.W. Grain Handling Authority’s (GHA) export terminal at Sydney on 17 July.

Following the appointment of Encik Shaharuddin Hj. Haron as the new Director-General of LPN in December 1984, he visited Australia from 14–21 April 1985 for discussions concerning the implementation of Projects 8308 and 8344 in Malaysia. He participated in a Project 8308 Team Leaders’ Meeting held initially at the University of New South Wales and then at the Ricegrowers’ Co-operative in Leeton. He also inspected the GHA terminal in Sydney, the Yanco Rice Research Station, and various storage and processing facilities of the Ricegrowers’ Co-operative and the Rice Marketing Board, including the rice mill at Deniliquin.

The ACIAR Liaison Officer in the Philippines, Miss Leonardo Nallana, visited the University of New South Wales and the Ricegrowers’ Co-operative at Leeton in October 1984 during a familiarisation visit to Australia. She held general discussions with Project 8308A personnel and inspected the facilities at the Ricegrowers’ Co-operative.

The Program Coordinator continues as Regional Editor for Australia and Asia of the Journal of Stored Products Research and as a member of the Permanent Committee of the International Working Conferences on Stored Product Protection.

Program Seminars

The first seminar with which the program is associated, on ‘Pesticides and Humid Tropical Grain Storage Systems’, was held in Manila from 27–30 May 1985.

A second seminar, on ‘Preservation of Grain Quality by Aeration and In-store Drying’, is planned for Kuala Lumpur from 9–11 October 1985. It will be conducted jointly with GASGA, the Malaysian Agricultural Research and Development Institute, Lembaga Padi dan Beras Negara, and the ASEAN Food Handling Bureau. The seminar is designed to present the current state of knowledge under broad headings of objectives, basic principles, and design systems, followed by a discussion of individual case studies. Particular emphasis will be given to simulation of the processes involved and
Seminar Program: Pesticides and Humid Tropical Grain Storage Systems

Address of Welcome — Mr F. Duban
Seminar Overview — Professor J.R. McWilliam
Introduction of Participants — Dr B.R. Champ
Introduction of Guest Speaker — Dir. V. Racho
Keynote Address — Minister J.T. Tanchanco

Pest Problems and Current Use of Pesticides
Chairman — E.D. Magallona; Rapporteur — M.G. Ramos
Pest problems and the use of pesticides in grain storage in Malaysia — A. Rahim Muda
Pest problems and the use of pesticides in grain storage in the Philippines — F.M. Caliboso, P.D. Sayaboc, and M.R. Amoranto
Pest problems and the use of pesticides in grain storage in Thailand — Chuwit Sukprakarn
Pest problems and the use of pesticides in grain storage in Indonesia — M. Sidik, H. Halid, and R.I. Pranata
Problems relating to pest control and the use of pesticides in grain storage: the current situation in ASEAN and future requirements — R.L. Semple

Some Constraints to Use of Pesticides
Chairman — R. Labadan; Rapporteur — R.L. Semple
Management of pest control in grain storage systems — D. Halliday and D.J.B. Calverley
Safety considerations in insecticide usage in grain storage — J.T. Snelson
Regulatory requirements for pesticide use — J.T. Snelson
Industry perspectives in pest control in the humid tropics — J.C. Gonzalez, Jr.
Developing country perspectives and use of pesticides — E.D. Magallona

Background Studies on Residual Pesticides
Chairman — B. Morallo-Rejesus; Rapporteur — J.T. Snelson
Background studies on the metabolism of residual pesticides in stored grain — D.G. Rowlands (presented by C.E. Dyte)
Behaviour of pesticide residues on stored grain — J.M. Desmarchelier
Biological efficacy of residual pesticides in stored grain at high humidities and moisture contents — P.R. Samson

Background Studies on Fumigants
Chairman — M. Bengston; Rapporteur — C.E. Dyte
Sorption and desorption of fumigants on grains: mathematical descriptions — H.J. Banks
Movement of fumigants in bulk grain — T.V. Nguyen
Action and inaction of fumigants — N.R. Price
The biological efficacy of fumigants: time/dose response phenomena — R.G. Winks (presented by C.J. Waterford)

Framework for Use of Pesticides
Chairman — D.J.B. Calverley; Rapporteur — J. van S. Graver
Principles of integrated use of chemicals in grain storage in the humid tropics — M. Bengston
Occurrence of resistance to pesticides in grain storage pests — B.R. Champ
Modelling of strategies to overcome resistance — H.N. Comins
Quality control and methods of application of pesticides to stored grain — J.M. Desmarchelier

Treatment Techniques
Chairman — V.F. Wright; Rapporteur — D.J.B. Calverley
Grain protectants — M. Bengston
Application of fumigants for the protection of grain and related products — H.J. Banks
Fabric spraying for pest control in grain storage — D.J. Webley
Use of pesticides in bag storage of grain — D.J. Webley
Use of carbon dioxide and sealed storage to control insects in bagged grain and similar commodities — P.C. Annis and J. van S. Graver

Integration of Chemicals into Storage Systems
Chairman — L.J. Fredericks; Rapporteur — M. Bengston
Use of pesticides in systems for central storage of grain — D.J. Webley
Use of pesticides for insect control in farm storage — V.F. Wright
An assessment of the benefits and costs of pest control methods in humid tropical grain storage systems — G.J. Ryland

Closing Session
Chairman — B.R. Champ; Rapporteur — E. Highley
Reports of Session Chairmen
Summary of Recommendations
Acknowledgements — M. Ramos
Closing Remarks — L.J. Fredericks
monisation of the regulations covering pesticide use in the various countries of the region, and the need to develop strategies to combat the alarming development of resistance to fumigants in the major pest species. As regards the former, the UNDP/UNIDO-sponsored Regional Network for Production, Marketing, and Control of Pesticides in Asia and the Far East has already done much. Seminar participants strongly supported its activities.

As regards countering fumigant resistance, the seminar recommended that a working party, drawn from all interested groups, be set up to examine the feasibility of developing a code of practice for fumigation in the region. The Working Party on Suggested Recommendations for Good Fumigation Practice in the ASEAN Region subsequently established has since held its first meeting.

The papers from the Manila seminar are being published in the ACIAR Proceedings Series.

Publications

Journal Papers


Conference Papers


Research Reports


Montiri Rumakom, Chuwit Sukprakarn, Kruawan Attaviriyasook, Kanjana Bhudhasamai, Lamai-


ACIAR Publications

ACIAR Grain Storage Newsletter No. 2 (December 1984).

ACIAR Technical Reports
