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**DEFENSE AIR COMMANDS AND CONTROL CENTER  
RESEARCH AND DEVELOPMENT PROGRAMS**

**TECHNICAL TEAM REPORT**

**Number 1**

**December 31, 1977**

**By**

**Norman C. Teter, Team Leader  
Dante R. de Padua, Team Member  
Harry Van Rullen, Team Member**

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**DEFENSE AIR COMMANDS AND CONTROL CENTER**

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## INTRODUCTION

The development of grain post-harvest technology is being tried out through a unique approach. A technical team of experts was pooled to stimulate, to coordinate, and to provide for consultant services on research and development of post-harvest technology.

Dr. Dante B. de Padua (IDRC) joined the team December 8th, 1976, Norman C. Teter (USAID/Kansas State University) March 7, 1977 and Harry van Ruiten (NETHERLANDS/SEARCA) November 18, 1977. Dr. Norman J. Beaton (CIDA) served with the team from April 25th to June 4th but elected not to make a long-term commitment as a team member. CIDA plans to appoint a team member trained in agricultural economics in the near future. Harry van Ruiten will report on the rice milling problems and issues in Southeast Asia after he completes his regional review during the next six months.

After a year from its inception, some operational problems are recognized in the context of the realities of the actual world.

1. Not all the major assistance agencies/governments interested in post-harvest technology joined the team effort; notably, Japan, Australia, Denmark, Germany, United Kingdom; agencies like TPI, IRAT, East West Center,

FAO, ESCAP, UNIDO; foundations like Ford, Rockefeller, Kellogg, and Magsaysay; and organizations like IRRI, OEC, IBRD, ADC, ADB and Food for the Hungry. Not only is there competition for resources, but the uncoordinated activities in countries, is duplicative, and compartmentalized. The failure of one program affects the others. Cooperation of the technical team with all post-harvest programs in Southeast Asia is desirable and is being actively pursued.

A listing of the Southeast Asia projects, both active and planned, that have come to the attention of team members is attached to this report. In keeping with the modern emphasis on systems analysis, projects are becoming increasingly integrated to include post-harvest technology in developmental planning. This trend should be encouraged.

2. While the technical team is well funded for its internal operations, the team has no funds to use in stimulating research or investigatory activities in the different countries. Consultant services, are more acceptable when advise is backed by funds that may be allocated to post-harvest activities. The board may wish to consider the solicitation of modest donor funds for direct research and training projects for team supervision.

## A REPORT OF TEAM ACTIVITIES

### Regional Activities

Two team members visited each country at least twice. The first visit oriented the team and the second visit followed up on projects identified by Members of the Board during its second meeting. Four regional activities were formulated and activated; namely, newsletters, a workshop, an exchange program and ASEAN co-operation.

Newsletter: Nine issues of a 5 page letter called Post-Harvest Digest contained articles to inform, promote, coordinate, and define research and development activities and needs in the region. The letter contains research and development news of projects and reviews of publications having subject matter of interest to those who are working toward improvement of post-harvest techniques. News items consist of team observations; news about research and development projects, and meetings; digests of books and reports; and articles about pertinent organizations and policies.

Distribution of twenty five Digests to each Board Member plus one hundred forty single copy mailings that have been requested, is supplemented by use of the letter

as a hand-out piece of literature to visitors. Public reaction to the letter has been good.

Workshop: A workshop covering milling, drying and storage, and to a lesser extent threshing, will be held in Bangkok, January 10-12, 1978. The meeting will give young project workers the chance to publicly present their findings, and to discuss them with older, more experienced research and development professionals.

Twenty four papers covering six countries and twelve agencies in the region give insights from the standpoint of the disciplines of engineering, entomology and economics. Proceedings publication is planned.

Exchange program: The exchange program this fiscal year aims to formulate grades and standards conducive to trade with minimum post-harvest loss. Participating exchange personnel are responsible to the Board, through the Team, for reporting their assessment of the grading situation and for recommending grade improvement. The team will consolidate the findings in a report to the Board.

BULOG of Indonesia has sent one man to each of the countries of Malaysia, Philippines and Thailand for one month. The report has not been received.

NGA of the Philippines are supplementing the programme exchange funds to send six men to Thailand,

Malaysia and Indonesia in January. In addition to studying grades and standards, these exchange grantees will study the engineering systems of the other countries.

The other three countries are hereby reminded that \$3,600 per country is available in programme funds to pay tickets and per diems for exchange as outlined in your document, "1977-78 Exchange" from the programme team.

ASEAN Sub-committee on Food Handling: Australia provided A\$2.3 million to the ASEAN sub-committee on food handling. An Asian Fruits and Vegetable Post-Harvest Center at Los Baños, Philippines, has been built and is operational under this grant. They have also released funds for the acquisition (by Indonesia, Malaysia and Thailand) of 45 farm type batch driers. A grains post-harvest working group has been formed, to which the Team has served as resource consultants in the formulation of research proposals. Under this, Malaysia is proposing to do work on limited oxygen (hermetic) storage of grain; Thailand on long-term storage of milled rice; and Indonesia on farm storage at the cooperative level. The sub-committee met in Manila, October 25-27, 1977 and the Philippine panel

invited Dr. Dante B. de Padua as a resource person. The ASEAN countries are submitting the details of their research proposals to the working group for consideration. The working group has invited the technical team as a resource panel at its meeting, January 31 to February 4, 1978 in Kuala Lumpur.

### In-country Activities

#### Indonesia

Faculties at Gadjah Mada and Bandung Universities expressed keen interest in research and to a lesser extent, extension programs in post-harvest. Bogor University faculty is concentrating more on teaching both graduate and undergraduate and the Michigan State University graduate program in post-harvest systems has three graduate students who plan to collect their doctoral dissertation data in Indonesia. The Central Research Institute of Agriculture at Bogor has a strong thrust in the post-harvest area. Their work centers at the Karawang laboratories. A guidance section has been formed in the sub-directorate of post-harvest technology in the Ministry of Agriculture. Because of the interest of several organizations (BULOG, BUUD/KUD, LP<sub>3</sub>, Transmigration, and Universities) in this field, guidance and

The team worked extensively with BULOG at the rice research center in Tambun. At present, the Tropical Products Institute has three resident experts located there. IDRC sponsors a drying project assisted by a CUSO volunteer. The team worked with both of these projects in discussing projects and project implementation. A thresher sent to Tambun at the request of the project leader was not used but it is requested for the use in IRRI/Michigan State University studies on post-harvest systems. FAO and UNIDO at one time had projects at Tambun, a station that received prototype equipment from many countries. The team recommended staffing, laboratories, equipment, and projects in research and training at Tambun. They outlined loss assessment techniques. Drawings were submitted for a proposed layout of dormitories, classrooms, laboratories, and research spaces. Detailed outlines were submitted for courses in warehouse management and manufacturing post-harvest machines. Detailed outlines are planned for three other courses; namely, milling, grain processing technology and engineering.

A new office, laboratory, library building and a prototype cooperative warehouse have been constructed at Tambun. A dormitory building has been started and a

guest house is planned this year. Staff development is proceeding through graduate training, exchange programs and workshop participation.

#### Malaysia

The LPN is the equivalent agency of BULOG in Indonesia or NGA in the Philippines. The LPN has constructed, over the past 3-4 years, rice processing complexes integrating drying, storage, and milling. All of these complexes are reported to be operational, but have encountered problems in drying and storage. In drying, the problem is not in the technical performance of the driers but in drier capability to handle the volume and type of harvest at the peak of the season. The bulk storage systems encountered caking of grain, usually at the bottom similar to the Philippines experience.

The technical team has liaison with the Malaysian Agricultural Research and Development Institute (MARDI). Malaysia under the ASEAN program is also recipient of 15 units of the batch type farm drier. MARDI has taken the view that farm drying should complement the LPN in-plant driers. MARDI has requested the technical team to organize a training program for extension engineers in Malaysia, to implement the utilization of the farm

driers in pilot areas. A draft program has been prepared, and given to Mr. Ahamad Kamari of MARDI. The training is planned for the next reporting period. MARDI has also requested assistance in the development of a 1/2 ton per hour continuous flow drier of the LSU type for both training and research.

#### Republic of the Philippines

The National Grains Authority (NGA) has made considerable headway in promoting post-harvest technology starting with their own facilities and operations. They use some 800 farm type batch driers in their procurement program as well as for farmer demonstration in connection with their farmers' training program. Their warehouses are being equipped with industrial capacity continuous flow driers. A design by Dr. Dante B. de Padua was manufactured locally, and is in the final stages of installation. Other manufacturers are being assisted. The NGA/IDRC team evaluated palay threshers for their adaptability as sorghum threshers prior to their purchasing demonstration units. The team is assisting the TRSD of NGA in preparing a comprehensive research and development program. Some studies under the program were submitted to the PCARR (Philippine Council for Agriculture and Resources Research) for

funding. The national post-harvest coordinating committee (an interagency committee) has met several times, primarily in formulating a credit scheme for acquisition of post-harvest facilities by farmers.

The other inputs to NGA that the team is working on are: (1) the preparation of a working document for the establishment of a regional grain post-harvest research and development institute as proposed by Adm. Tanchanco. The proposal has to be cleared with the President before it is officially submitted to possible donors; (2) the design and development of plant type driers - and associated equipment; and (3) NGA informally requested the services of team member lecturers in the NGA regional staff training.

IRRI research projects carried out in the Bicol River Basin and in Central Luzon provided basic data pertinent to post-harvest. The integrated project on rural development with emphasis at Central Luzon State University at Muñoz, the University of the Philippines at Los Baños, and the National Food and Agriculture Council, GOP has project implications for post-harvest. A closer liaison with the integrated project and with the cooperatives project is sought. IRRI requested the team to review the draft of a grain test laboratory manual to be prepared for the IRRI laboratory staff.

### Singapore

A system of rice handling, storage, fumigation and packaging was suggested for the Singapore government and merchants. The system consists of pallet handling through sealed fumigation chambers with methyl bromide nozzles and circulating fans. Storage in the chambers is followed by dumping the bags into receiving hoppers with "Phostoxin" pellets if needed, and holding in hopped bins for 6 days, followed by packing in plastic and sealing.

A series of items were suggested for manufacturing including grain grading, handling and processing equipment. Of especial interest are moisture meters, aspirators and similar costly laboratory items. It was suggested that Singapore work with BULOG on their bag handling problem and a belt systems for the double width BULOG warehouses was suggested.

### Thailand

Thailand is a rice exporting country, and the post-production activities for export are handled exclusively by the private sector under government regulations. As acceptable high yielding varieties are developed to compare favorably with the grain quality traditional varieties, and irrigation and drainage faci-

lities are constructed, a new generation of post-production problems will be spawned as they have occurred in other countries. These will be in reaping, threshing, cleaning, and drying at the farm level, for the crop that is harvested in the rainy season.

The Ministry of Agriculture identified farm drying as the area for research and development where IDRC assistance was obtained. The engineering division of the Department of Agriculture has successfully developed their version of a farm type batch drier under the IDRC supported project. It differs from the UPLB design in that the primary heat source is a direct heating rice hull furnace, and the fan housing is fitted with a cyclone-flying-ash collector. The alternate kerosene pot burner was modified by increasing the flanges and utilizes a fuel nozzle to allow the use of automobile diesel oil which is cheaper and more readily available in rural Thailand. In its initial introduction with farmer cooperators, it was reported that farmers were enthusiastic about the drier. The cooperation of the department of agricultural extension has been sought for the wider demonstration introduction of the drier. Bulletins and radio and TV releases were being prepared. Since the Thai farmers practice diversified farming, questions

on its performance with other cereals, and legumes have been asked. The drier performance with these other grains is being evaluated. The drying bin will be modified as a tray type drier for other non-granular products. Thailand, is also the recipient of the Australian-ASEAN assistance, for 15 units of the farm drier. The 15 units will be locally manufactured utilizing the Thai-design. The Department of Agricultural Extension has agreed to work with the technical team in organizing a course for their extension technicians on the use of the farm drier. Manufacturing in Thailand is not a problem, as industry has the capability to turn out farm machinery that has a market potential.

The selection of Thailand as host for the regional workshop will enable others working in rice post-harvest in the region to study what the Thais have done. The integrated rice processing complex of Mr. Kamchai, local manufacturing shops, and the engineering division's prototype rice mill are typical of the pragmatic, practical approach of the Thais to their development efforts. In the rice milling industry, innovations that have been recommended by milling experts have been adopted readily.

In cooperation with the Department of Agriculture at Kasetsart, expansion of their laboratory is planned.

for grain testing. Assistance is being given on the size, equipment and staffing of this laboratory. Harry van Ruiten drew plans to be used for estimating cost of the new construction.

#### PROBLEMS AND ISSUES IN SOUTHEAST ASIA

The technical problems are:

1. Low efficiency of available commercial mechanical threshers for the wet season's extremely wet harvest.
2. Design and development of a drying system to match the existing constraints. These are: extremely wet grain, small volumes at point of harvest, large volumes of mixed varieties and grades at secondary points of aggregation, high cost of drying equipment and high cost of operation, and slim margin for paying the drying costs.
3. Bio-physical problem of bulk storage in the humid tropics (see Figure 1).
4. Low efficiency of village mills.

Technical storage problems: The climatograph graphically illustrates storage problems imposed by the Southeast Asia climate. The climate is optimum for molds and insects and is in equilibrium with paddy above

13 percent wet basis. Paddy stores better than any other grain, one reason for its preference as a cereal of Southeast Asia. Brown rice especially when hulled with emery coated discs, and under-milled rice stores poorly but well milled rice stores well for a limited period of time.

The flow of paddy from an average Central Luzon farm is shown in Figure 2. This shows that farm storage is of considerable importance. The flow and storage points beyond the farm have not been adequately studied and defined. Storage studies based on the US model that do not take fully into account the restrictions in transport systems are ill-suited to storage requirements of the area. The emphasis on buffer stocks controlled by NGA, LPN, BULOG, and Department of Commerce make large storage structures (3,000 T and up) a necessary part of the grain flow system. Storage bins are the surge bins of the flow from farm to consumers and must be sized according to time and rate of flow.

An ideal flow system minimizes storage that is distributed throughout the system, from producer, to buyer, to miller, to wholesaler, to retailer and to consumer, each having a storage with first in, first out priority. The ideal can serve as a model but

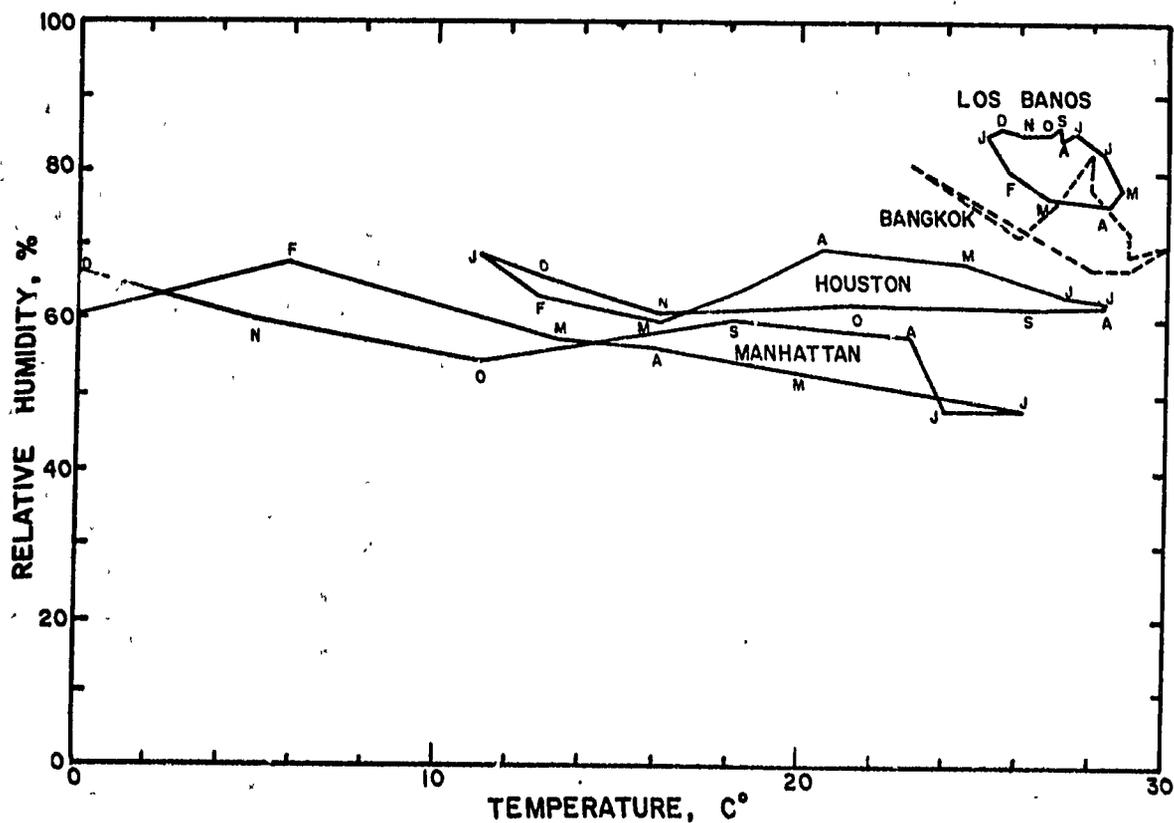


Figure 1. Average monthly temperature and relative humidity at four locations.

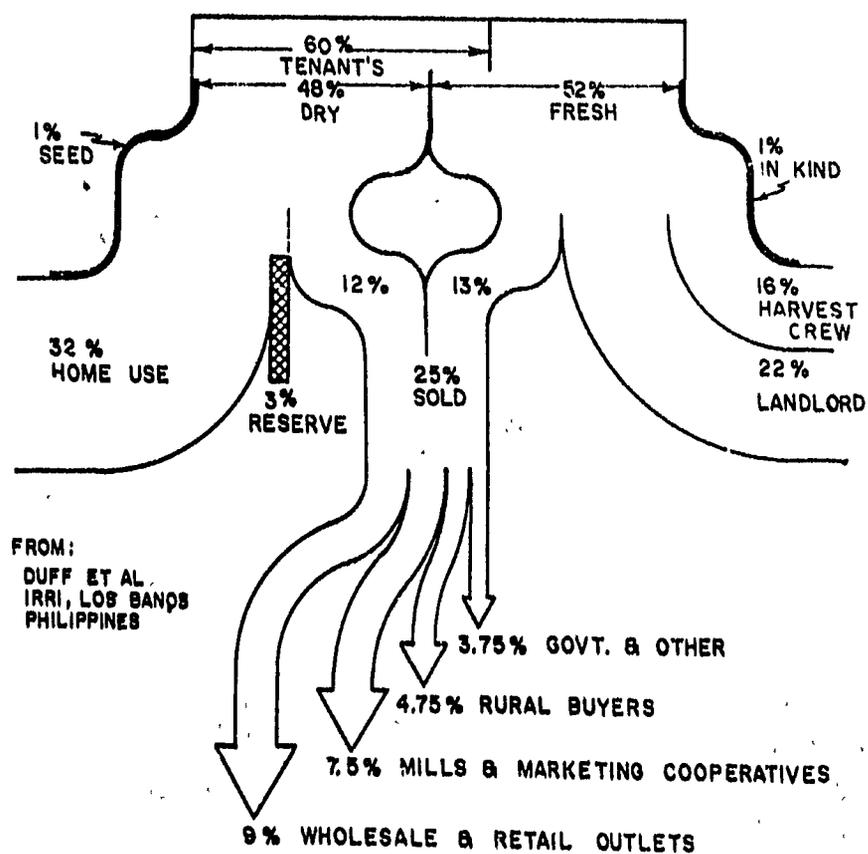


Figure 2. The flow of rough rice from farms of Central Luzon, Philippines. (1974-75)

constraints dictate deviation from the ideal. Constraints are yield variability from month to month, grain quality variability from wet to dry seasons, wet grain, transport bottlenecks, market price depressions at times of excess, imperfect evaluation for trade, cost of excess storage capacity, and the variation in judgement of the appropriate excess storage needed.

Storage in Southeast Asia has greater variability in need than that of developed countries because the friction to flow is much greater than that of developed countries. Costs of transport, drying, and farm storage are generally higher than those of the temperate zone. Movement into and out of storage is difficult and results in a tendency toward excessive time in storage, the new stock bypassing the old in storage.

Some localities have poor sanitation around the storage site, giving harbor for insects and rodents. Observations made up to this time lead to the conclusion that dry grain and good sanitation would almost eliminate warehouse storage losses of paddy.

Field infestation of mold is very serious in maize, and to a lesser extent in grain sorghum. Field and field pile molds of alternaria, cephalosporium, fusarium, giberalla, mucor, and rhizopus are followed

by aspergillus and penicillium which may start in the field and proliferate soon after harvest. It seems likely that aspergillus, penicillium and fusarium exist to the point of presenting a health hazard in maize. Field molds infest paddy in the wet season. In bad weather, paddy comes from the field with a musty odor. Bacteria and to a lesser extent yeasts also attack the straw and husks of paddy in the wet season, especially paddy lodged to the ground with driving rain. The practice of storing paddy on the straw results in heating and development of mustiness in the stacks, before threshing, yet this practice is the only practical one under the present harvesting conditions.

Sometimes weeks are required to dry paddy down to 14 percent. The paddy is laid in the field, stacked, threshed and spread, resacked, and respread, through a combination drying-and-storage phase of handling.

The nature of the handling methods and the mats used for drying, indicate that a loss of 1/2 to 1 percent for each handling could be expected. If this is true, the losses in the drying-storage period for wet season harvest may be quite high. Repetitious drying results in contamination and lowering of the milling quality.

High moisture, warm grain presents serious moisture migration problems. Water moves from a warm

area to a cool area. The bottoms and side walls of metal, and concrete bins, may drop to dew point during the night. This results in caking problems on the bottom, on the walls, and sometimes in the crown of the pile in bulked bins. Condensation in the crown is not as common as in temperate regions. Extensive bulk storage capacity has been abandoned because of this problem. Studies made of bin temperatures and reports of caking have not been published. It is impossible to accurately document the processes leading to moisture migration and spoilage. More research is needed.

Theoretical calculations indicate that judicious aeration at times of lowest humidity will prevent condensation problems. The volume of aeration needed for paddy at 17 percent moisture wet basis is 4 times that of the temperate zone ( $0.3 \text{ m}^3/\text{min}$  per  $\text{m}^3$  of grain). This volume requires excessive horsepower for deep silos but appears reasonable for horizontal storage. Aeration must be more carefully managed than in temperate zones.

Bags should be reduced in size because excess weight per bag creates handling problems, losses from use of hooks, and reduced ventilation of the center of the bag. Bag handling and storage fits the conditions of labor, moisture, climate and transport. Bulk handling,

although cheaper in systems designed to accommodate bulk, presents problems that should be carefully studied before a recommendation is made for bulk handling and storage. Warehouses for bag storage need to be improved. Fumigation is difficult. The most common fault is the lack of provisions for making the warehouse air tight. Over ventilation in bad weather can result in moisture build up. Floors need to be built above normal ground elevation. Bag conveyors need to be installed to improve grain movement.

In the storage situation the variation of needs within countries is as great as that between countries. Indigenous farm storage practiced in remote self-sufficient cereal areas appears to be well cared for and losses of paddy do not appear to be severe in farm storage.

Village storage varies from poor to excellent, and large warehousing requires continual vigilance. Insect species causing the most damage are lesser grain borer, rice weevil and saw-tooth grain beetle. Flour beetles are abundant in storages of bran and small particles. Moth attacks are fairly well controlled with chemicals.

In summary two points of storage appear to suffer major losses:

1. The combination drying-storage before threshing, and after threshing before grain is down to 14 percent.

2. The long time warehouse storage where inadequate sanitation and drying is accomplished.

#### PLAN OF WORK JANUARY-JULY, 1978

The timing of the schedule of activities remains flexible to cooperate with the representatives of organizations working in post-harvest. Each team member has a detailed plan of activities which is generally described as follows.

Principle work emphases of the team are devoted to a workshop in Bangkok and publication of proceedings of the workshop; training courses in Malaysia, Indonesia and Thailand where the members will serve as faculty; a continued consultation service on research and development of facilities and projects; the publication of two Post-Harvest Quarterly's; the planning of a well-structured exchange program for 1978-79; and the publication of technical data and papers. The next technical report will contain a report on the milling problems and issues in Southeast Asia.

Representation is planned at the TPI seminar in London and the GASGA meeting in Rome. Plans are made to meet the deadlines for Advisory Board Reports. An Advisory Board Meeting is anticipated the first week of June.

Team members plan on-site consultation with emphasis on training in all countries except Singapore. Training in drying will coordinate with the ASEAN project of making 15 flat bed driers available to Indonesia, Malaysia and Thailand and with the NGA regional training program in the Philippines.

Specific projects for consultative services this year are:

**Regional:**

1. Proposal for a regional post-harvest Research and Development Center.
2. Review of publications and manuals:

National Academy of Sciences

IRRI Grain Testing Laboratory Manual on Post-Harvest Loss

3. ASEAN projects especially the Thailand long-term rice storage project.

**Indonesia:**

1. Training course content.
2. Aeration studies in the New Zealand silos.
3. Coordination of post-harvest work.

**Malaysia:**

1. A laboratory model of a 1/2 T/hr. continuous flow drier for MARDI.
2. Drier short course (First 2 weeks of April).

**Philippines:**

1. Technical assistance:
  - a) NGA/UPLB/IDRC equipment evaluation, grain handling, and bulk storage.
  - b) USAID/KSU integrated project.
  - c) NGA (TRSD)/PCARR/NSDB
  - d) NGA (GID) local manufacturing of continuous flow driers.
2. Regional NGA staff training.
3. Special research
  - a) With UPLB on development of a recirculating-air fluidized bed jet drier for rapid drying of extremely wet grain, with or without straw.
  - b) With CLSU at Puyat farms Santa Rosa on innovative racks or flaming techniques for wet season harvest.

**Singapore:**

Advise on manufacturing of post-harvest equipment.

**Thailand:**

1. The long-term rice storage project.
2. A report on milling.
3. Work with training.

SOME PROJECTS AND RELATED ACTIVITIES CONCERNING GRAIN AND  
LEGUMES POST-HARVEST RESEARCH AND DEVELOPMENT IN  
SOUTHEAST ASIA

December 31, 1977

INDONESIA

1. BULOG

- a. Testing, evaluation and introduction of batch-type farm driers. IDRC.
- b. Aeration in bulk in horizontal storage. TPI. KSU.
- c. Insect control in bagged storage. TPI.
- d. Bulk bin aeration. New Zealand. TPI.
- e. Warehousing at BUUD & DULOG levels.
- f. Training facilities and courses for Provincial Quality and Pest Control Teams.

2. CRIA (Lembaga Pusat Penelitian Pertanian)

- a. Development of Karawang as a rice post-harvest research center. IRRI/USAID (Formerly FAO).
- b. Farm storage and village storage of rough rice. ASEAN/Australia.
- c. Milling and drying studies at Karawang.
- d. Maize storage.

3. Institute of Technology, Bandung

- a. Design, testing and evaluation of post-harvest equipment including the UPLB drier design. ASEAN/Netherlands.
- b. Rice hull utilization. Ministry of Agriculture/ASEAN.

4. Gadjah Mada University

- a. Extension program on farm drying.
- b. Research projects on
  - (1) Rice hull furnace.
  - (2) Electric heat for drying.
  - (3) Drying response to different air flow rates and temperatures.

5. Bogor University

- a. Systems analysis. MSU/USAID/East West.
- b. Economic studies of markets.

6. Ministry of Agriculture

- a. Sub-directorate of post-harvest. Jl. Haji Ten 24, Jatirawamangun RT 01/RW01, Jakarta.
- b. Cooperative promotion of dryers under the cooperative programme.
- c. Quality and pest control training. FAO/World Bank/USAID.

**MALAYSIA**

1. MARDI (Malaysian Agricultural Research and Development Institute)

- a. Storage and grading (propionic acid, wet paddy storage).
- b. Drying and harvesting (continuous flow dryers).
- c. Handling and storage.
- d. Training programs on post-harvest.

2. Department of Agriculture

- a. Extension Services.
  - (1) Specialists at the technical centers advise on post-harvest practices.
  - (2) In-service training for specialists in youth education.
- b. Rodent control. British.

3. Agricultural University at Serdang

- a. Graduate and undergraduate theses.
- b. Publication of informational and teaching materials.

4. MADA

- a. Farm storage structures.
- b. A study of field loss. TPI.
- c. Equipment evaluation for MUDA.

5. LPN. Research on improvement of their own operation.

**PHILIPPINES**

**1. University of the Philippines at Los Baños**

**a. Research.**

- (1) Handling of wet rice by aeration. IDRC.
- (2) Milling parameters. IDRC.
- (3) Rice-hull furnace. NFAC.
- (4) Rice-hull gasification. NFAC.
- (5) Bulk storage (with NGA). IDRC.
- (6) A precleaner and an LSU type dryer with tempering.

**b. Teaching.**

- (1) Graduate and undergraduate theses.
- (2) Short courses on grain processing.

**2. NGA (National Grains Authority)**

**a. Research**

- (1) Rice and sorghum thresher evaluation. IDRC.
- (2) Small mill evaluation. IDRC.
- (3) Evaluation of mills in a pilot area.
- (4) Bulk storage (with UPLB). IDRC.
- (5) Value analysis of batch type farm dryer. IRRI/MIRDC.

**b. Training**

- (1) Training of the regional NGA staff.
- (2) Farmer training.

**3. IRRI/USAID and Others**

**a. Bicol River Basin.**

- (1) Performance evaluation of village mills. UPLB.
- (2) Post-harvest labor requirements. Univ. of Hawaii.
- (3) Post-harvest systems evaluation.

**b. Development of threshers, dryers, handling equipment.  
(Industrial Extension - area wide).**

**c. Storability variation in rice varieties.**

4. Central Luzon State University, Nueva Ecija
  - a. Integrated Agricultural Development Program. USAID/KSU.
  - b. Teaching.
    - (1) Laboratories being developed.
    - (2) Training courses to be developed.
  - c. Seed processing. USAID.
  - d. Social impact of post-harvest systems.
5. Farm Cooperatives. USAID. (Processing & Marketing).

## SINGAPORE

Singapore Institute of Standards and Industrial Research

- Storage of milled rice.
- Product survey for manufacturing post-harvest equipment.

## THAILAND

1. Department of Agriculture, Kasetsart, Bangkok
  - a. Development of a batch type dryer. IDRC.
  - b. Village mill improvement.
  - c. Post-harvest losses. Kasetsart University.
  - d. Manufacturing post-harvest equipment. IRRI.
  - e. Long-term milled rice storage as affected by processing methods. ASEAN/Australia.
2. Thammasat University. IRRI.
  - Milling economics.
3. Better Living Co., Ltd. Kamchai Iamasuri, private miller.
  - Development of an integrated complex centered around a rice milling operation.
4. Asian Institute of Technology
  - a. Ferro cement structures for farm storage.
  - b. Solar dryer performance.

c. Computer analyses of air flow requirements for drying and aeration.

5. FAO

- a. A milling manual is being written.
- b. Workshops at Alor Setar, Malaysia on post-harvest losses and one in India on farm storage were sponsored this year.
- c. Publications.

Fumigation.

Storage.

Post-harvest manual.

6. ESCAP

- a. Economic report on rice movement.
- b. A rice milling specialist has reported on Thailand needs.

7. Royal Thai Government. USOM.

Seed processing center. Mississippi State University.