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AOT ARDA

IRRI CROPPING SYSTEMS PROGRAM

Crop improvement efforts directed toward the Asian rice farmer have as their goal an increase in farm productivity and efficiency with a resulting increased income to the farm family.

IRRI's efforts have thus been directed toward two major areas:

1. Better rice varieties and the production of technology to effectively use them;
2. Development of a cropping systems technology to increase cropping intensity on Asia's rice farms, making more efficient use of available farm resources.

This second aspect is the focus of the cropping systems program.

OVERALL OBJECTIVES:

The objectives of IRRI's cropping systems program are:

1. To develop research methodology in cropping systems and to extend that methodology to cooperating programs;
2. To develop and assemble specific multiple cropping technology for our target agroclimatic zones.
3. To feed back information on needed basic and developmental research to the concerned agencies.
4. To encourage and assist national production programs in our target agroclimatic zones in achieving increased farm productivity through increased cropping intensity.

The IRRI cropping systems program should be evaluated in 1980 in terms of the increase in cropping intensity and productivity in target agroclimatic zones as a result of IRRI's input into national programs both in terms of program development and specific technology.

THE POTENTIAL FOR INCREASE OF CROPPING INTENSITY

Asia's rice is largely produced on small farms (1/2 of all farms are less than 1 ha, 3/4 are less than 2 ha) without irrigation. Of that portion which is irrigated (19 percent in Southeast Asia), only a small fraction receives year-round water. In these latter areas continuous rice is grown, with 5 crops in two years being a common practice. Partially irrigated areas produce one or at most two crops of rice a year, depending on the duration of water availability. In a very few such areas the main crop of rice will be followed by an upland crop of short duration which makes use of a limited water supply insufficient for a second crop of rice. In rainfed areas (which produce 70 percent of Asia's total rice) only a single crop of rice is grown. In more and more of these rainfed areas farmers are beginning to follow rice with other crops to better utilize their available growing season.

Data from Burma illustrate the prevalence and variety of multiple cropping patterns.

Cropping pattern		Area planted (1000 ha)
Rice-rice	Rainfed	44
Rice-peanut	"	178
Rice-chickpea	"	133
Rice-black mung bean	"	58

Cropping pattern		Area planted (1000 ha)
Rice-other pulses	Rainfed	44
Sesame-rice	"	133
Jute-rice	"	89
Jute-rice-peanut	"	13
Cotton-rice	"	80
Non-rice double cropping	"	267
Non-rice mixed cropping	"	58
Total cropped area in Burma		9330

Thus about 13 percent of the area is double cropped, including the irrigated areas.

Other countries have a somewhat higher cropping index (Dalrymple, 1971).[1/] A close look at areas where cropping intensity is high will indicate that they usually have physical resources typical of large portions of Asia. One can even find, in Indonesia for instance, areas of low rainfall having an extremely high cropping intensity. Here population pressure on the land has forced farmers into efficient utilization of their physical resources.

Initial estimates of the portions of Asia falling into different rainfall categories show that a major portion of the land area can support two crops a year as seen by the following:

[1/] Dalrymple, D.G. 1971. Survey of multiple cropping in less developed nations. USDA, Washington D.C. (sample multiple cropping indexes: China 147, India 114, Indonesia, 126).

Percentage of land in Bangladesh, Indonesia, and the Philippines that fall under 5 major rainfall categories.

	Rainfall category	Bangladesh	Indonesia	Philippines
I	less than 3 wet* months		25	12
II	3 - 4 wet months	23	40	28
III	5 - 6 wet months	72	30	37
IV	7 - 8 wet months	5	5	21
V	more than 8 wet months			2

* 200 mm or more per month

Research data combined with farmer experience in the more intensively cropped areas indicate that with three wet months, rice and a short duration upland crop can usually be grown. With 5 or more wet months, two crops of rice are possible if the first is direct-seeded using an early-maturing variety. Five months of rain can support a range of upland crops following rice, depending on soil type.

It is evident that there is great scope for increasing cropping intensity in the rainfed and partially irrigated rice farms in Asia.

The crops that are most suited to the large portion of these areas and for which markets are most readily available are, in addition to rice:

The legumes

1. mung bean
2. soybean
3. cowpea
4. peanut

Coarse grain	:	5. corn
		6. sorghum
Root crops	:	7. sweet potato
		8. cassava

In portions of the region sesame, chickpea, wheat, jute, or cotton are major crops with rice.

It is estimated that the above list includes roughly 90 percent of the area presently double-cropped with rice, with vegetable making up most of the rest. The first 6 crops probably cover 75 percent of the area as a whole, and in the warmer humid regions they are almost exclusively used. The first 8 crops are being used in IRRI's core program, while some of our cooperators use one or more of the others.

IRRI PROGRAM ORIENTATION

The relative attention given to different aspects of the cropping systems program changes over time as objectives are accomplished and as cooperating national programs become functional.

AGROCLIMATIC ZONE DESCRIPTION[1/]

Cropping patterns and crop intensity are highly environment-specific. Key factors determining their make up are: amount and duration of water availability, soil type (determining fertility, drainage and tillage characteristics), farm size and labor density, and markets. It is essential, both for purposes of locating test sites as well as

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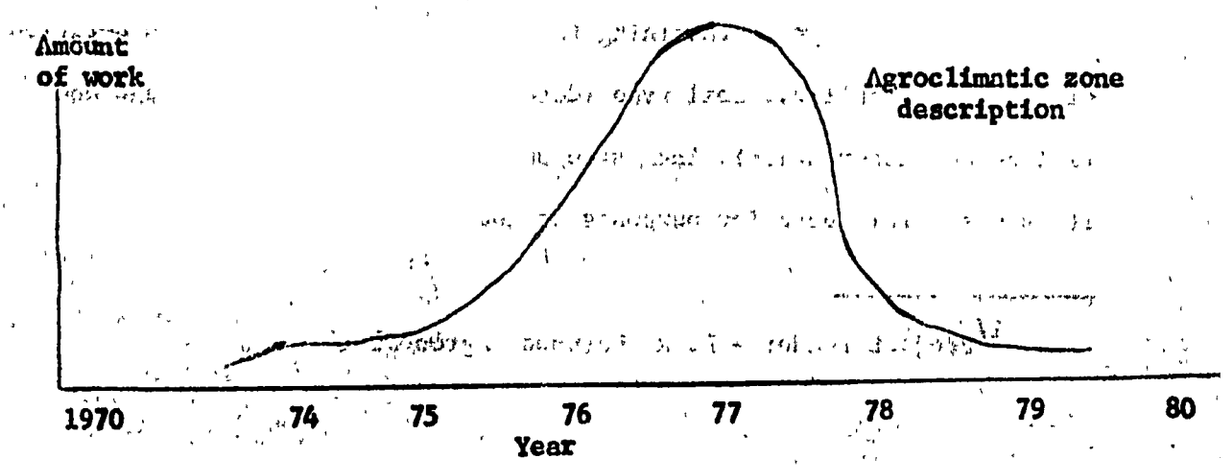
[1/] Project Leader - R. R. Harwood, Agronomist.

for extrapolation of test results across areas, that the critical parameters be suitabliy described. Work to date has concentrated on delineating rainfall zones having given crop potential. During 1976 and 1977 the rainfall and soil classifications will be largely finished for Southeast Asia. Present cropping systems work is now being conducted in specific zones classified by water availability and soil type. We find that these two parameters give the smallest geographical area of classification, while market availability and labor density give the highest.

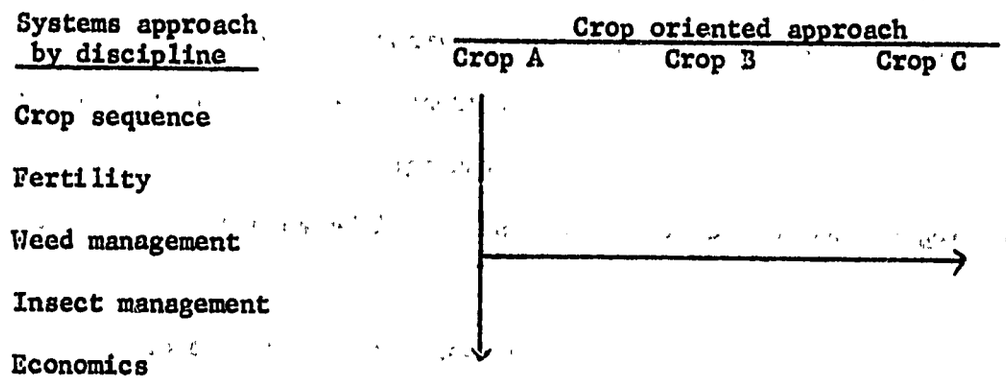
The initial approximation of soil and water classification was done by a consultant team in 1973. During 1974-75 the Bangladesh climatological survey was completed. The climatological definition of the Philippines and of Java will be completed in 1975. We have, in 1975, 9 man-months of a climatologist's time. In 1976 a senior scientist will be added for 6 months and a joint program carried out with Reading University with ODA support. During 1976 also a full man-year of senior scientist time will be devoted to soil classification. The classification of socio-economic parameters will follow:

A time profile of this total classification effort is as follows:



DEVELOPMENT OF CROPPING SYSTEMS RESEARCH METHODOLOGY

The development of environment-specific cropping patterns and the various aspects of their management requires an approach oriented toward the entire pattern rather than toward individual crops as follows:



The entire program integrates research in both directions, and is always pattern-oriented.

While components of a cropping systems may be researched in the controlled environment of experiment stations or even in the semi-controlled environment of research-managed trials in farmers' fields, the entire system can be evaluated only under farmer management. We have thus developed the concept of "farmer-participant" research, where the farmer becomes amember of the research team. His particular contributions to the team are his skill in managing his own resources, and his keen sense of judgement in evaluating suitable technology in his own environment.

These research techniques have been worked out and are being extended to cooperating programs in the region.

CROPPING SYSTEMS NETWORK[1/]

Justification:

The key element in the IRRI network program is the establishment of a network of experimental sites in major rice growing areas in Asia in collaboration with national programs. The test sites are carefully selected to represent the major areas of responsibility for our collaborating national programs and the agroclimatic zones of the rice growing areas. At least one test site will be selected from each major rice growing country.

The objectives of this network are several fold:

1. To provide a mechanism for joint program planning and review between the major national programs of the region and IRRI.
2. To provide a series of data points on the Asian agroclimatic grid for determining the cropping system potential in major zones of the region.
3. To enable IRRI to extend relevant methodology and technology into national programs.
4. To provide a mechanism for long-term upgrading of national efforts.

Summary of accomplishments:

Seven experimental sites are operational in 1975. These are:

1. Oton and Tigbavan, Iloilo, Philippines - rainfed and partially irrigated rice;

[1/] Project Leader - V. R. Carañgal, Network Coordinator and R. R. Harwood, Agronomist

2. Manaoag, Pangasinan, Philippines - rainfed and partially irrigated rice;
3. Tanauan, Batangas, Philippines - upland rice;
4. Indramayu, West Java, Indonesia - partially irrigated rice area;
5. Central Lumpang, Indonesia - upland rice; rainfed and partially irrigated rice;
6. Joydepur, Bangladesh - rainfed and partially irrigated rice.

We have identified this year four sites in Thailand (all rainfed and partially rice areas), three sites in Sri Lanka (rainfed and partially irrigated rice areas) and one site in Malaysia. Next year additional sites will be identified in India, South Korea, Burma, and Nepal. By 1977, we expect to have a network of 20 experimental sites collaboratively working with IRRI in the region.

Collaborative planning:

A working group was created to help IRRI develop general plans for collaborative research in the network, review research results, evaluate, and where appropriate, modify the research program and develop annual work plans. The working group is composed of program leaders from collaborating countries, the IRRI program leader and network coordinator, and two scientists invited from outside the network. The present members are the following:

1. Richard R. Harwood - IRRI
2. Damkhoong Chandrapanaya - Dept. of Agriculture, Thailand

3. Diosdado Carandang - Univ. of the Philippines at Los Baños
4. Walter Fernando - Dept. of Agriculture, Sri Lanka
5. Virgilio R. Carañgal - IRRI
6. Ajit Singh Sidhu - MARDI, Malaysia
7. Sjarifuddin - CRIA, Indonesia
8. Zahidul Hoque - Bangladesh Rice Research Institute
9. B. Krantz - ICRISAT, India
10. Dave Norman - Ahmadu Bello University, Nigeria

The group first met after the cropping systems workshop at IRRI d will meet again in Indonesia on November 3 to 8, 1975. We plan to at in countries where the collaborative work is underway to give the mbers an opportunity to see each other's work and also to visit the tional cropping systems research program.

Periodical workshops and seminars are a part of this program.

Recommended procedure in each site: The cropping systems methodogy developed at IRRI was further refined in the recent cropping systems kshop at IRRI (March 17-21, 1975). The working group recommended a ree-phase approach including the definition, design, and testing of stems technology based on farmers' involvement.

Experiments will be done in farmers' fields with farmers involved conducting the experiments. Some trials will be completely managed research workers but all the cropping pattern trials will be managed farmers with assistance from the research workers. The major search work in each site is as follows:

1. Study existing conditions;
2. Development of improved cropping patterns;
3. Fertilizer, weed control, insect control experiments which are superimposed in most cases on the cropping pattern experiments;
4. Varietal evaluation of food crops (rice, corn, sorghum, soybeans, mung, peanut, cowpea, and sweet potato);
5. Socio-economic surveys and analysis.

The studies mentioned above are being conducted in the three Philippine outreach sites. The details of these studies will be disucssed by the scientists concerned in their presentations. In Indonesia, the work started in August, 1975 and a survey of existing conditions in the two sites is finished. Plantings started in October, 1975.

Composition of the research team: The team in each site should have a minimum of five professional staff composed of a coordinator, two agronomists, an economist, and a crop protection specialist plus field assistants. The number will vary from site to site depending on the volume of work. The team will live in the project area in order to insure efficient implementation of the research projects. The extension worker covering the selected villages, although not a regular member of the team, should be involved in the baseline survey and in selection of farmer cooperators. He should be informed of the research developments in the project. Likewise, the extension chiefs at the provincial level should be involved in selecting the experimental sites and be informed

of the progress of the research. This way research findings can easily be fed to their ongoing production programs.

Tie-up with national research systems: The collaborative research is conducted with national research programs. In some countries, the collaborative research may be the beginning of a new cropping system research program while in others the program hopes to strengthen and intensify present research efforts.

In the Philippines, the three sites are considered part of the national research program. IRRI staff are directly managing the sites in cooperation with the Bureau of Plant Industry, a research agency of the Department of Agriculture. The IRRI program leader is a member of the National Multiple Cropping Management Committee, a coordinating committee composed of representative from different government agencies involved in multiple cropping not only of rice-based but also corn-based systems. IRRI is also involved in the applied research and production programs in the Philippines.

The two experimental sites in Indonesia are partof the national research system. The project leader is also the head of the cropping systems project in the Central Research Institute for Agriculture, the institute implementing the cropping systems research program. With the collaborative project, research will be intensified in cropping systems with emphasis on rainfed and partially irrigated rice areas. It includes training of extension workers not only in the two research sites but also at the IRRI station, and a mechanism for establishing applied research in key locations similar to the two test sites.

Obviously, the tie-up with national programs will vary from country to country. It will depend on the existing research programs, the organizational set-up of the cooperating agency, and the national production programs. We will not set up an independent program but will work with existing organizations.

Future plans:

By 1977 approximately 20 sites will be operational. The IRRI program inputs will then begin to give more attention to support of forthcoming national production programs.

TRAINING[1/]

Justification:

The training element is critical to the strenghtening of national program capability in cropping systems in basic and applied research as well as in production efforts. Several avenues are available for this training, in the form of seminars, workshops, short courses, individual in-service participation, and degree and post-doctoral fellowships. The central aspect of this training is the formal training course conducted by staff of the Rice Production Training and Applied Research Department.

Aimed at training research and production extension personnel for the IRRI outreach program focusing on the development of strong national programs.

[1/] Project Leader - L. D. Haws, Senior Scientist.

The training component of the cropping systems program is designed to train personnel from cooperating countries in research and extension techniques. The first two or three training programs are organized to train research people in research methodology. This includes establishment of field plots, collection and analysis of data, and writing a final report.

The second phase of the training component will be to train teams of trainers in extension and production technology so that strong training programs can be started or strengthened in the art of cropping systems.

Objectives:

A course in cropping systems was first offered by Dr. Bradfield in 1969 at IRRI. Since that time, 96 students have been trained in the technology of multiple cropping. The course was taught in that department until 1975, at which time the responsibility of training was given to the Rice Production, Training and Research Department.

The first cropping systems course in the RPTR was offered in January 1975, to 25 students from five cooperating countries. The objective of this course was to produce trainees who will be able to:

1. Know and perform cultural practices involved in growing the various field crops commonly used in cropping systems.
2. Identify and solve production constraints of these crops when grown alone or in combination with other crops.
3. Conduct scientifically designed, applied and adaptive research to solve problems in cropping systems in their respective areas.

4. Recognize and apply the important principles of communication to extend information and to train researchers, extension workers and farmers in the new technology of crop production.

Summary of accomplishments:

The activities of the students were divided almost equally each day into practical and applied work with the mornings being devoted to work in the fields and lectures presented in the afternoon. An expression of involvement by the staff of both IRRI and UPLB can be shown by the fact that 84 resource speakers were involved in the course. All lectures were recorded and catalogued for use by students who, because of language problems, were not able to understand in detail the lecture material as presented orally. These tapes could be checked out to individual students at their convenience. Also, a two volume syllabus (about 1100 pages) of the lectures given was compiled. Each student received a copy of this syllabus and a set of slides to aid him in his work when he returned to his home country.

The first cropping systems course was held from January to June 1975. These dates have now been changed in an effort to have the training course held during the time of year when the crops to be studied are grown. Therefore, the cropping systems course will be held from October to February following the rice production training course.

Field experiments are also conducted as a major part of the training course. The students outlined and established research experiments in the field. A partial list of these experiments are listed here.

1. The effect of N rates on the yield of sweet corn intercropped with mungbean, peanut and sweet potato.
2. The effects of N-levels on the yield of field corn at various plant population.
3. Various crop combinations based on corn.
4. Comparison of different levels of management on peanut production.
5. Intercropping corn with 2 mung varieties under four levels of weed management.
6. Corn insect control applied research trial.
7. Herbicide screening in corn.
8. Effects of crops and crop combinations on some major insect pests incidence.

ture plans:

The Cropping Systems Training Course as now offered at IRRI is lieved to be a very satisfactory beginning. However, a maximum of only 35 students can be accommodated each year. With the need for many ched people in this area, the number that can be trained now is completely unsatisfactory.

In order to influence many more people in the area of cropping systems training, two main efforts will be made in the coming years to overcome this shortage of trained people.

1. Recruit teams of people to be trained at IRRI. These trainees can then help in the outreach program by establishing training programs in their own country.

2. Prepare a course in cropping systems to be used in the countries of the trainees. This will be accomplished by recording edited lectures presented at IRRI. The language of the country to use the tape will be used. Slides will be made to demonstrate the needed reference points. Slides and tapes will then be synchronized for presentation. All an institute would need to present a course similar to the one given at IRRI would be:

   a. A team trained at IRRI or other training center
   b. Syllabus
   c. Tape-projection combination
   d. Taped lectures
   e. Slides of techniques
   f. Classroom and land for applied research plots.

A summary of the total training effort to date is given as follows:

Man-months of formal training*

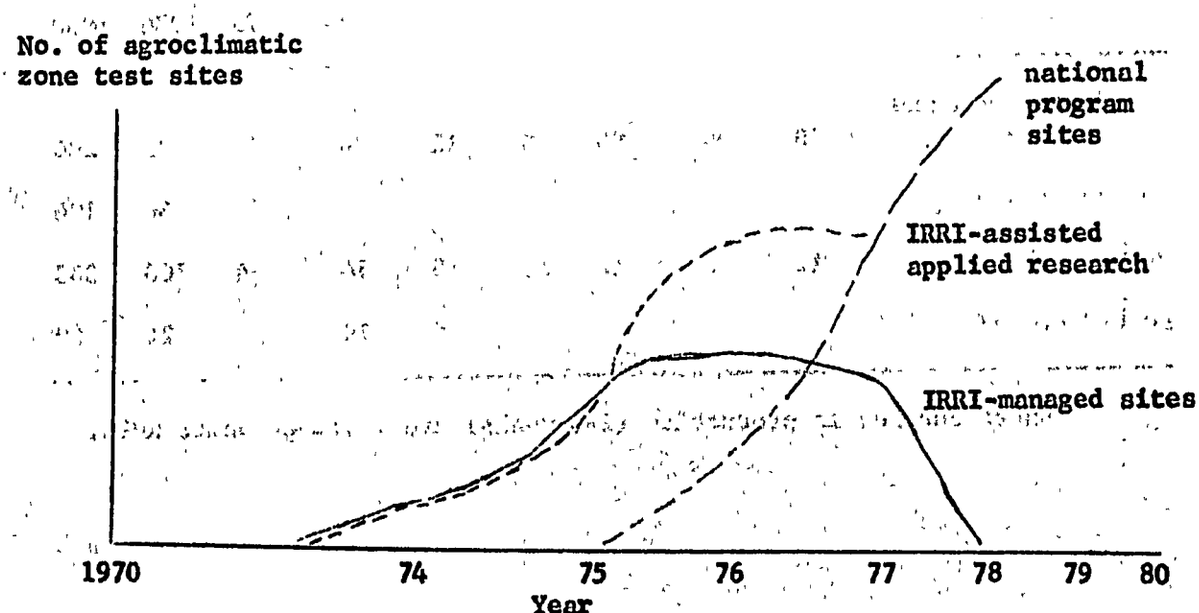
Category	1969	1970	1971	1972	1973	1974	1975	1976	1980
Non-degree research training	60	96	96	20	12	76	125	200	200
Teacher training							15	30	100
Degree scholars	12	2	12	12	18	54	54	100	300
Post-doctoral					6	10		24	60

* short courses in production (2-3 weeks) are included under RPTR.

THE DEVELOPMENT AND EVALUATION OF TECHNOLOGY

CROPPING PATTERN STUDIES[1/]

The complete research package on cropping patterns is being carried out by IRRI with assistance from the Bureau of Plant Industry in three locations in the Philippines. The first site in an upland rice growing area of Batangas, is in its third year. This site is representative of the physical potential in many upland rice areas of the Philippines. Research results have been reported in several papers (Herrera, et.al., 1975; Samson, et al., 1975; Garrity, et al., 1975). Research will be phased down on this site in 1976. The other two sites are in rainfed lowland rice areas. Research there is in its first year. Approximately 100 farmer cooperators are involved at each site in cropping pattern studies and in supportive research. IRRI will maintain 3 sites through 1977 when it will phase down its cropping pattern studies as national programs come on line with additional sites. These network sites are summarized below:



1/ Project Leader- R. R. Harwood, Agronomist

Availability of production technology for specific zones

The first production recommendations for an agroclimatic zone will be made for a portion of the upland rice area in the Philippines in early 1976. The recommendations will be made in the form of cropping pattern alternatives, their resource use, management requirements and expected returns. Recommendations for rainfed paddy areas will begin in 1976, with data increasing rapidly as the many national programs become active.

Extrapolation of results across zones

With up to 30 sites potentially on line by 1978, together with numerous applied research test sites, an extensive data matrix will be available. From these data the shifts in crop potential can be seen as water availability, soil type, and other parameters change. IRRI research will then enter its ultimate phase, that of extrapolation of production potential across zones. This will be computer-assisted, based on the data bank being constructed from the many test sites.

VARIETAL EVALUATION[1/]

Justification:

One of the major inputs in increasing cropping intensity and yield per unit area in small scale farms is the development of improved varieties of crops adapted for intensive cropping. International Institutes and other centers are concentrating their efforts in developing high yielding varieties acceptable to farmers. There is need of a more concentrated

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[1/] Project Leader - V. R. Carangal, Network Coordinator

effort to insert these materials into ongoing programs. Recently the International Development Research Center (IDRC) funded the University of the Philippines at Los Baños (UPLB) to screen varieties and lines developed by the international institutes and centers for characters of major importance in intensive cropping. UPLB is concentrating on upland crops such as corn, sorghum, soybeans, mungbeans, sweet potato, tomato, and eggplant. IRRI is screening other important food crops suited to planting after rice such as peanut and cowpea. Of course, IRRI is developing rice varieties through its GEU program.

Accomplishments:

The most promising varieties and lines from the screening together with locally developed varieties are tested in the cropping systems network of experimental sites throughout South and Southeast Asia. In ddition, we are providing trials to institutions and organizations working on cropping systems in countries collaborating with the network. The cooperators in 1975 are the following:

1.	Bangladesh	- Bangladesh Rice Research Institute
2.	Indonesia	- Central Agriculture Research Institute
3.	Philippines	- IRRI outreach sites in Batangas, Iloilo and Pangasinan
4.	Sri Lanka	- Agricultural Research Station, Maha Illuppallama
5.	Burma	- Agricultural Research Institute, Rangoon
6.	Malaysia	- Malaysian Agricultural Research and Development Institute
7.	Thailand	- Dept. of Agriculture, Kasetsart University and Khon Kaen University

Legumes, corn, sorghum, and sweet potato will be evaluated after the main crop of rice. Corn will also be tested before rice. The evaluation program is not a uniform testing. However, there will be uniform plot size, replication number, and data collection. The number of entries will vary from country to country depending on the extent of their breeding program. UPLB and IRRI will contribute from 10 to 15 entries. The number of entries per crop and number of trials for distribution in 1975 are shown in the table below.

Crop	No. of entries	Number of trials							
		Thai-land	Indo-nesia	Sri Lanka	Burma	Malay-sia	Bangla-desh	Philip-pines	Total
Corn	11	2	2	1	2	-	1	6	13
Sorghum	14	4	2	1	2	1	1	6	16
Soybeans	15	4	2	1	2	1	1	4	14
Mung bean	10	6	2	1	2	1	1	6	18
Peanut	10	-	-	1	2	-	2	1	5
Cowpea	11	4	2	1	2	1	1	6	16
Sweet potato	10	increase	-	-	-	-	increase	3	3

Sweet potato roots were sent to Thailand and Bangladesh for seed increase. Only two corn trials were planted in the Philippines and Bangladesh, one soybean trial in Thailand and two trials each of cowpea and mung bean in Thailand. Data are not yet available. The rest of the trials indicated above will be planted after rice from September to December, 1975.

In the Philippines we evaluated the promising lowland rice varieties developed by the national breeding program and IRRI in Iloilo and Pangasinan outreach sites. One set was direct-seeded in May at each site, and this was followed by transplanting in September. Another was transplanted at each site during the regular season. Promising upland rice varieties are also evaluated in the Batangas outreach. (Data will be available in November).

One hundred eight cowpea lines from International Institute of Tropical Agriculture were planted in one-row to two-row plots for seed increase. In October, we will conduct a replicated trial for observation to identify the promising varieties. Twenty-three peanut varieties from Thailand and India were introduced and increased for observation in a replicated trial in October.

We are introducing more improved varieties of cowpea from the International Institute of Tropical Agriculture and other national programs and peanut from ICRISAT and the U.S.A. for evaluation to identify varieties suited after the main crop of rice.

Future plans:

The number of trials will increase in 1976 with the increase in the number of experimental sites involved in the cropping systems network. We plan to evaluate the promising varieties of upland crops including rice in each site. In addition, institutions and organizations involved in national coordinated cropping systems research will be included in the evaluation program.

PEST MANAGEMENT[1/]

Objectives:

To provide a practical pest management package of recommendations for each cropping pattern that can be followed by a good farmer. The technology will be fitted to the conditions at each test site and tested on that site.

Present pest management technology concentrates on each crop individually. Our objective is year-round pest management fitted to the resources of the small farmer (limited capital and land combined with high labor capability). We are primarily interested in using the available technology already developed in pest management and will fit this technology to the conditions of each site. This technology will mainly be insecticides.

Summary of accomplishments:

For each site we have prepared a profile in outline form listing for each crop the major and minor insect pests as well as their natural enemies. This will be revised as we learn more and will help us to interpret the pest complex in terms of future research needs, who does the research, and being able to compare pest complexes between sites, both in the Philippines in the network.

An outline in rough form is presented below for Batangas, the first of 3 sites for which we have the most information.

1/

A total of ten feasible cropping patterns are being studied for their insect management problems. These patterns include the 8 major field crops studied in the cropping systems program.

Profile of the Major Insect Pests of Batangas Cropping Pattern

Rice

White grub
Leucopholia irrorata

Rice bug
Leptocorisa acuta

Corn

Corn borer
Ostrinia furnacalis

Earworm
Helicoverpa (*Heliothis*) *armigera*

Rice weevil (storage)
Sitophilus oryzae

Mungbean - Cowpea - Soybean

Aphid
Aphis craccivora

Bean fly
Ophiomyia phaseoli

Pod borers
Lycaenidae - *Catochrysops crejus*
Helicoverpa (*Heliothis*) *armigera*
Maruca testulalis

Bruchid weevil
Callosobruchus

Armyworm - Cutworm - Semilooper
Pseudaletia, *Chrysodeixis*
Spodoptera, *Mocis*

Sorghum

Armyworm - Cutworm - Semilooper
Pseudaletia separata
Spodoptera litura
Chrysodeixis chalcites

Webworm
Pyralidae (unidentified)

Sweet potato

Sweet potato weevil
Cylas formicarius formicarius

Armyworm - cutworm
Pseudaletia separata
Spodoptera litura
Mocis frugalis

Peanut

None

Future plans:

The pest management research will concentrate on these crops grown in the proper sequence and will provide an input on the cost of crop protection for each pattern, leading to an assessment of the feasilibity of growing that cropping pattern. It may turn out that the pest problems are too great for a particular pattern and that the farmer should turn to other alternative ones.

1. Methods of control:

Resistant varieties - Lowland rice is far ahead of other crops in having resistance to insect pests. The upland crops including upland rice generally do not possess resistance. As the varieties become available they will be tested at each site. We are hopeful that in the near future we will have at least

Biocontrol - We are aware that there exist powerful entomophagous agents acting in farmers'fields on at least some pests, probably those that are of minor status now. Basically we don't want to introduce new technology (insecticides) which will upset the presently-acting parasites and predators. Our role will be to determine the relative effectiveness of these agents presently acting in farmers' fields and as much as possible maintain that effectiveness so as not to induce more pest problems. Predators tend to move from crop to crop and hence can be managed over the cropping season. We are encouraging their survival from crop to crop.

Cultural control - We will not greatly emphasize this method in terms of experimentation on our part. Most of the benefits here, mainly time of planting and sanitation practices will be learned from field observations and sampling over successive plantings of each crop. We plan to work on the effect of weeds and weeding on insect pests. Intercropping has been shown in our trials to reduce some insect pests but the benefits are little known and hence won't receive our emphasis for some time.

Insecticidal control - This will be the mainstay for our pest management technology. Right now for most pests there are recommended insecticides that have been tested elsewhere. Our role will be to test for methods of most efficient application

This will include proper timing of application. We will work more intensively on those pests which have had the least amount of testing, emphasizing the most important pests at each site.

We will emphasize those insecticides that are available to farmers now. If for some reason these are inadequate we will test others. This test work will involve two aspects: The first is the more basic aspect of effect of the insecticides on the total insect community and the second is production testing for production recommendation.

2. Comparison of pest profiles between sites:

Similar pest profiles will be drawn up for Pangasinan and Iloilo. These profiles will help when it comes to extending the pest management technology to other geographic areas of similar rainfall patterns and even will allow interpretations to be made for eareas of dissimilar rainfall patterns. This will provide a format for determining what pests to expect and the probable pest management strategies.

The presence or absence of biocontrol agents between areas of similar rainfall patterns will be instructive in terms of future projects involving the transfer or parasites and predators between regions. This is important within the Philippines as well as in the region of the Cropping Systems Network in Asia.

3. Plant diseases, nematodes, and rodents:

Our emphasis will be on insect pests but we cannot exclude diseases, nematodes and rodents from our package of technology.

UPLB has a large Department of Plant Pathology and their results plus those of other institutions, namely AVRDC, will be incorporated.

These problems have less options in terms of pest management solutions and are beyond our scope of IRRI research emphasis in terms of our basic research other than to screen for resistant varieties.

Nematodes - We are engaged in a cooperative project with UPLB on nematode control by crop rotation. Nematodes appear to be important only in upland areas.

Rodents - The Rodent Research Center is located nearby to IRRI and has a very active program in practical methods of rodent control in the field. Rodenticides are available and can be used where necessary.

4. Cooperative tie-ups:

As we are working on so many crops and pests it is important to learn of new developments coming from other institutions as well as research and production groups. We are endeavoring to understand the farmers practices in pest management and the resources that he has at his disposal, land, capital, labor. The economics section of C.S. IRRI is a source of further information on farmers practices.

5. C. S. Network:

We have a close tie-up in Indonesia with the entomologists

going pest managment trials in the 2 sites. The tie-up will be on a professional basis where we plan to exchange scientific information and coordinate research projects.

Similar arrangements will be made in other Asian countries as the network becomes more developed.

WEED MANAGEMENT[1/]

Justification:

Luxuriant weed growth is a major problem of tropical agriculture. It is estimated that crop losses due to weeds in the tropics are two to three times greater than in the temperate zone.

An assessment of the major tropical crops would probably indicate that weed problems have either limited the yield of the crop or are a major item in the cost of production. In many instances, the farmer spends more time weeding than on any other farm operation. In fact it has been postulated that the principal limiting factor to the size of tropical farms is the number of weedings during the period following planting. One of the greatest limitations to the introduction and acceptance of multiple cropping throughout the world could be weeds and the problems associated with controlling them.

Weeds are probably a greater problem in a sole crop or in simple crop associations than in the multicrop multistoried associations that occur in many parts of the tropics. The complete cover provided by a mixture of crops not only helps in protecting the soil but may reduce

the need for weeding by competing with weeds.

In recently cleared fields or newly cropped areas broadleaved weeds are the major problem but in fields that have been cropped several years grasses -- which are said to be more difficult to control -- provide the principal competition. If more crops are grown in sequence per year, the tendency for grass weeds to be more prevalent in older crop areas could well be accelerated.

The majority of the weeding in the developing countries is carried out by hand or with simple hand tools. These methods are generally effective means of weed control but they are tedious, time consuming and require much labour. Labour is expensive and at times in short supply either because it cannot meet the high requirement at a given time or because it is permanently inadequate.

For large scale farmers herbicides may offer the most practical, effective and economical means of reducing weed competition, crop losses and production costs. For smaller scale farms the problem remains much more difficult. The cropping pattern that the small-scale farmer uses does not lend itself to the introduction of herbicides. In addition, for economic and educational reasons herbicides cannot be exploited nearly so readily on small-scale farms.

Repeated use of the same herbicides over a period of years leads to a build up of tolerant weeds. This can be prevented by rotating crops, rotating herbicides or by removal of these tolerant weeds by other weed control methods when they appear.

Despite the great potential of herbicides weed control in cropping systems in the tropics will not depend on them alone but will probably be based on a combination of all available means of weed control -- cultural, mechanical, chemical and biological.

Objectives:

To provide a weed management package for the major cropping patterns used by rice farmers, starting with the patterns presently used at the outreach test sites.

Summary of accomplishments:

In all cases an integrated approach is being used combining tillage, crop sequence, time of planting, competitiveness of the variety, plant spacing and in many cases, chemical. It has been found that in intensive sequences the weed problem itself is really determined by past weed management practices. Our management techniques involve manipulation of weeds across the entire cropping pattern.

Along these lines, recent trials at IRRI have indicated that:

1. a. The use of herbicides to control annual weeds in transplanted rice has created ideal conditions for *Scirpus maritimus* -- a difficult to control perennial sedge -- to multiply rapidly.

   b. Rotating an upland crop (corn/peanut intercrop) with transplanted rice, reduced greatly the amount of *S. maritimus*, compared with herbicides.

2. For long term control of the more difficult and persistent weed species a low rate of herbicide followed by light weeding and relatively high plant densities is preferable over other treatments designed to give a commercially practical level of weed control.

3. A greater increase in weed density occurs in the later stages of growth of short-statured crops (rice and legumes) than with tall-statured crops (corn and sorghum). Shading by the tall crops did not alter the species of weeds present.

4. In upland rice, combinations of dense stands or leafy varieties, low rates of herbicide and limited mechanical tillage gave good weed control and greatly reduced troublesome weeds such as Cyperus rotundus. At low chemical rates, the predominant weed in the second season was Digitaria sanguinalis -- a comparatively easy to control weed -- which affects crop yield less than C. rotundus.

5. A lack of vigor and decrease in total growth occurs with certain photo-period responsive mungbean varieties when planted between November and January. The result of this lack of vigor and failure to achieve complete ground cover leads to aggravation of an already difficult weed control problem.

6. The response of rice to nitrogen fertilizer application is markedly influenced by the adequacy of weed control.

Future plans:

1. To examine existing and proposed cropping patterns in the outreach sites to determine weed problems and suggest possible means of alleviating them. To suggest possible cropping patterns that may be superior on the basis of weed control to those in existence or those proposed.
2. To screen various crops and varieties for their competitive ability against weeds.
3. To determine optimum planting densities, row spacings, etc. for greatest competition against weeds.
4. To examine various land preparation techniques during the dry season and between crops in the wet season in an attempt to reduce time spent on these operations and postplanting weed control without loss in yield or increase in the time spent on some other field operations (e.g. planting).
5. To determine whether intercropping and mixed cropping are advantageous with respect to weed control.
6. To determine the effect of time of planting following the start of the wet season on subsequent weed growth and weed control.
7. To examine in association with the entomologist the effect of weeds growing in association with the crop and the removal of these weeds on insects and diseases.
8. To try to determine why weeds are sometimes worse in type and intensity in scientific trials in farmers' fields than those in

9. To examine the effect of cropping patterns and agronomic practices on weed populations in an endeavour to prevent the build up of undesirable weed species or if these species have built up to intolerable levels to try to learn by manipulating cropping sequences and weed control practices how to reduce them to acceptable levels or to replace them with easier to control weeds.

10. To determine optimum economic levels of weed control in various crops and cropping systems by comparing available weed control techniques -- alone and in combination.

HERBICIDE SCREENING IN UPLAND CROPS[1/]

Objectives:

To endeavor to find a herbicide that will kill the majority of weeds in crops that are most suited for adoption into multiple cropping programs in Asia without causing crop damage.

Justification:

In general, weed control practices presently used in the developing countries are slow and arduous. Quite often weeding is delayed until planting is finished due to insufficient labor being available to carry out both operations. By the time weeding is started crop yield reductions have already occurred.

[1/] Project Leader - S.K. De Datta, Agronomist and K. Moody,

The answer to these problems may be in the use of herbicides which can be more selective and thorough in their action than mechanical methods of control and require much less time in their application.

Some people have expressed the concern that herbicides are too costly to be used by the majority of farmers in the tropics. However, in many parts of the world, increasing labor costs and the unavailability of labor at critical times are rapidly causing the use of herbicides to become more economical than hand labor. However, there are problems associated with the introduction of herbicides into the small scale farmer's operations.

Farmers in developing countries typically grow several crops each of which may require a different herbicide. The possibility of mistaken usage, with serious crop damage resulting obviously arises. It would be ideal if there was one herbicide that would be safe for use in all the crops grown in a given locality.

In many areas in order to reduce weed control problems and to maximize land usage upland rice is often grown in association with other crops. Herbicides must therefore be evaluated for their possible effects on crops grown in association with or in sequence following upland rice.

Any herbicide that is safe in several unrelated crops is also likely to be ineffective against several weed species. These tolerant weeds can be controlled easily by other weed control methods provided that the herbicide quantitatively controls the major weed species present.

Results obtained:

In 1975, two herbicides -- butachlor and butralin -- applied pre-emergence at 2 kg a.i./ha controlled the majority of weeds in upland rice, corn, sorghum, peanut and mung bean without causing crop damage. Weeds not controlled by these herbicides were *Cyperus rotundus*, *Commelina diffusa*, *C. benghalensis* and *Ageratum conyzoides*. A new coded compound MON 0358 looked promising for weed control in rice and several other upland crops.

Planned research:

To continue to search for one or more herbicides that will control a wide spectrum of weeds in all the crops grown in association with rice or in a given area without causing crop damage.

SOILS RESEARCH

A senior scientist will be added in 1976 to add strength to present work in this area. Classification of tillage characteristics of the major paddy soils at different moisture levels will give an approximation for the probabilities for successful tillage over time at given locations. The methods for conversion from puddled to upland conditions will continue to be studied for a range of soil types.

Fertility studies will concentrate on efficiency of use of fertilizers in different crop patterns. The total amounts required differ markedly with both crop pattern and how and when it is applied. When lowland paddy is rotated with upland crops this consideration

becomes critical. Results from these trials will then be incorporated into zonal recommendations for the patterns.

ECONOMICS OF RICE-BASED CROPPING SYSTEMS[1/]

Justification and objectives:

Economic research is undertaken to assist in the intial design of more productive rice-based cropping patterns, and once their biological feasibility has been shown, to evaluate their acceptability to farmers and their potential impact on food production.

At the design stage, the effort is two-fold:

1. Locating economic phenomena in existing cropping systems which are related to multiple cropping and which can be technically improved, extended to other locations, or otherwise exploited; and
2. From study of the levels of farmers' resources and their present utilization, recommending areas of biological research that are most likely to increase the productivity of farms through multiple cropping.

Farmer acceptance of a new multiple-cropping technology is clearly necessary before it can result in increased food production. Therefore tests of acceptability are conducted by assessing the farm level economics of the tecnology -- mainly its profitability. Also, in order to arrange priorities for research and extension of multiple cropping technology,

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[1/] Project Leader - E. C. Price, Associate Agricultural Economist

evaluation is also conducted of the size of the potential increment in food production, the locations where the technology is applicable, and who are the likely beneficiaries of the new technology.

Summary of accomplishments:

Much of the effort since a program in cropping systems economics was begun at IRRI, has been toward the development and testing of a methodology, and formation and training of a research staff.[2/] But significant advances into the design and evaluation of multiple cropping technology have also been made[3/].

Field work was begun in 1973 in Batangas, Philippines, and in 1975 it was extended to several barrios in Iloilo and Pangasinan Provinces. A similar methodology as that which has been used at these locations, also intended for the design and evaluation of multiple cropping technology, has been adopted for research at two sites in Indonesia and at two sites in Thailand with IRRI collaboration.

[2/] Banta, G.R. 1972. Economic evaluation of multiple cropping systems. IRRI Saturday Seminar series.

Banta, G.R. 1973. Procedures and tools of economic evaluation of multiple cropping. Paper presented at the 1st Multiple Cropping Workshop, Indonesia, Sept. 18-20, 1973.

Banta, G.R. 1974. A philosophy of surveying cropping systems.,IRRI

[3/] Antonio, E.V. and G.R. Banta. 1974. Multiple cropping in a Batangas barrio. IRRI Saturday seminar series.

Banta, G.R. 1974. Preliminary findings on resources characteristics and their utilization on corn farms in the Philippines. IRRI

Frio, A.L.and G.R. Banta. 1974. Socio-economic factors associated with systems in selected Batangas barrios. IRRI Saturday seminar series.

Design of more productive cropping patterns:

The design of more productive cropping patterns is mainly in the hands of biological scientists. For its part, the economics research into the design of cropping patterns is based on two postulates:

1. The principles according to which farmers themselves have designed cropping patterns, if discovered, can be a guide to a more productive technology, and
2. New cropping patterns which utilize farm resources more fully than present patterns are likely to be more productive.

In either case, the necessary analysis must be based on a thorough examination of existing farm resources and technology.

Within seven research projects on the economics of cropping systems, the subprojects which mainly contribute to design of new patterns are:

1. Weekly land, labor, and cash utilization on farms in three Philippine locales
2. Cost and returns of farmers cropping patterns in three Philippine locales
3. The role of critical inputs in differentiating cropping systems by locale
4. Trends and seasonal variation in prices of major food crops in countries of Southeast Asia.

Some of the research results obtained within the past year lead to the following diverse and tentative conclusions regarding pattern design in three Philippine settings:

1. The management capacity of farmers is a stronger determinant of cropping intensity than labor availability or size of farm
2. Cash inputs are highly complementary with the labor input such that certain kinds of cash intensive technology is likely to be labor-absorbing.
3. Water control is a major component of the technology of rainfed farming; variability of rainfall is a strong determinant of the level of investment in bunds and drainage, and consequently of the costs and feasibility of multiple cropping.

Pattern evaluation:

There have been several approaches to the evaluation of new cropping patterns and they are indicated by the subprojects listed below which contribute mainly to this objective.

1. Cost and returns of experimental cropping patterns.
2. Role of critical inputs in determining the adoption of new cropping systems.
3. Systems analysis and simulation of rice-based cropping patterns at the farm level.
4. Macro analysis of cropping systems in agroclimatic zones of Southeast Asia.

Under the first subproject, the straight-forward analysis of the profitability of new cropping patterns is conducted. This presently is the most frequently used approach but increasingly a simulation model, which incorporates a cost and returns routine, will be used.

Cost and returns analysis of agronomic trials in Batangas barrios in 1974-1975 supported recommendations to a Philipine government agency for applied research trials for the 1975-76 crop years. These trials and their evaluation will also likely result in the development of a Philippine program to encourage farmers to produce sorghum after rice in Batangas.

The last subproject: macro analysis of cropping systems by agro-climatic zone is an attempt to analytically extend the results from research at the Philippines outreach sites and from collaborating sites in other countries, to zones where work is not conducted but the resorces and economic characteristics of which are know.

Future plans:

The program for economic analysis of cropping systems at IRRI is expected to increasingly focus on cross-national applicability of research results, based on a mapping of agroclimatic and economic variables, and to increasingly collaborate with researchers elsewhere. The latter will be facilitated by a program for short-term training at IRRI in the economic analysis of cropping systems, and the standardization of survey forms and data formats among cropping systems researchers.

CONTINUING DEVELOPMENT OF PRODUCTION TECHNOLOGY

The problem research areas of varietal testing, soil fertility, weed management, insect management, and socio-economic evaluation within the context of adapted crop patterns will continue through 1980, even

after national programs have assumed most of the responsibility for crop pattern studies. This, combined with concentration on functional models contributing to the ability to extrapolate over climatic zones will then be the major research contribution.

APPLIED RESEARCH AND PRODUCTION PROGRAMS[1/]

Justification:

The transfer of knowledge from the basic researcher to the farmer has been a major constraint to increasing the welfare of the farm population from the beginning of the modern ear. Our concept of applied research is to receive information from research institutions, to assemble and test it in farmer's fields and to develop a package of inputs which will reduce risk, and increase the farmer's income. Finally, to help develop a national program in which the package of technology can be used by all who want it. This is the major challenge and justification for this portion of the program in the training and applied research department.

Objectives:

1. To increase the well-being of the Asian farmer by:
   a. Providing the technology that will increase yields in rice and upland crops in his farm.
   b. Helping to determine production constraints and eliminating them.

[1/]Project Leader - L. D.Haws, Senior Scientist

c. Establishing, through provincial and national agencies, production programs.

Summary of accomplishments:

Sweet Corn Project

With the wonderful year-round climate in the Philippines, one can plant almost any plant anytime of the year and it will grow. Generally, in Luzon, Mindanao and Iloilo, there is sufficient ground water to start crops in April before the start of the rainy season. The supply of water is also sufficient to prevent loss from drought that may occur during the rainy period or to finish upland crops that may be planted after the last rice crop has been harvested.

A major constraint on upland crops, however, is a suitable stable market. Soybeans, corn and sorghum are all imported into the Philippines but they can all be grown in abundance here. With this in mind, a project was started with sweet corn to see if a market could be developed for this product. Commissary officers were contacted at the Air Force Base at Clark Field and the Submarine Base at Subic Bay. They have a combined population of about 50,000 people. They also have the possibilities of purchasing food for many thousand more. They were immediately interested in purchasing the corn or any other vegetable that could be furnished in good quantity and quality. The farmer-cooperator in this project was soon making ₱15,000/ha for sweet corn. Contacts were made with other food outlets, i.e. supermarkets and restaurants. The Manager of A & W Rootbeer wanted to become an agent and sell corn in the

Greater Manila area where he had established contacts. It was evident from this small experiment that markets can be developed even if one has to start from a very low base and build it up.

A similar program has been started for sorghum and it appears that there are many people trying to buy sorghum. Someone must work to bring together the producer and the buyer of the product. In my opinion, this should become a very important part of the applied research program.

IRRI-ACA-DAR Cooperative Project:

The Department of Agrarian Reform (DAR) has approximately 477 compact farms throughout the Philippine Republic that they are trying to develop into economic agricultural units. These farms occupy about 300,000 hectares of land. The Agricultural Credit Administration (ACA) is responsible for making loans to these farmers of DAR to aid in the development of the farm lands.

Working with the officials of ACA-DAR in Urdaneta, a project was organized in which IRRI would provide technical help for direct-seeding rice in two compact farms in Pangasinan. This project was entitled "Supplemental irrigation in producing direct-seeded rainfed rice". The objective of the project was to use the ground water available at these farms to start a rainfed crop of rice at the correct time or at the onset of the rains (April 15). This ground water could also be used in case of a dry period during the rainy season and save a crop and thus reduce the risk of crop failure due to drought.

The project was started later in the season than desired but about 400 hectares of rice were brought into the project. Funding was late and as a result most of the pumps were not installed on time. However, even without the pumps, many good harvests of IR1561 were obtained. The farmers are in the midst of harvesting their crops at this time and results (yields) will be available for the review in December. This project will continue for the next year with upland crops now being planted for a second crop and the rice crop being planted next year (April 15). Pumps are now with the farmers for use next year. If this technology can be demonstrated successfully in Pangasinan, the results can be introduced into the 477 compact farms of DAR with immediate benefits to these new land holders.

IRRI-PCAR Cropping Systems Project

This is a joint project between IRRI and the Philippine Council for Agricultural Research (PCAR). This project involves 32 provinces in the Philippine Republic. The project has two main objectives:

1. To evaluate the potential of producing a second crop of rice or various upland crops following the direct-seeded rice crop in rainfed (bunded) rice areas.
2. To evaluate the economics of the two- and three-crop system as compared to the traditional method of rice and upland crops.

The harvests from the first crop of rice are being evaluated at this time and results will be available for the December meeting.

The upland crops have been planted in 10 locations in northern Luzon on light soils. Additional upland crops will be planted on heavy soils after the second rice crop is harvested. This project should demonstrate the possibility for getting two crops of rice and at least one upland crop on heavy soils and one rice crop and two upland crops on light soils.

Both these projects have been institutionalized so that the results obtained from the applied research plots can be moved directly into a provincial or national program to increase production, and thus the farmer's income. As a result of this work, the farmer's standard of living will be considerably increased.

Production programs

IRRI scientists are now serving on the national management committees guiding production programs in the Philippines. The first such program is now underway and will target around 50,000 hectares in several provinces to come under multiple cropping from the present single crop in 1976. An Indonesian program is likely, based on test site results in 1977. The network coordinator, as his organizing role phases down in 1976, 1977, will spend more of his time with such programs, while Dr. Haws will concentrate his attention on coordinating the technical support and working as a member of the production management committees.

Future plans:

There are three main areas where work will be concentrated over the next five years.

1. Adapting research results to national needs. This will remain a major effort in our applied research program. The work will involve an economic analysis for production costs and returns of eight upland crops, i.e. Peanut, Corn, Mung, Cowpea, Sweet potato, Irish potato, Sorghum, Soybeans planted after rice.
2. Market evaluation. In cooperation with appropriate national scientists, efforts will be made to locate and establish markets, local and international, for the upland crops mentioned above.
3. National production programs. Enough information has been gained in the Philippines and elsewhere so that we are confident we can teach the techniques of organizing production programs with rice and some upland crops. This work will be carried out in countries where our outreach programs are established. We will serve on national management committees to help organize these programs.

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