

COLLABORATION IN AGRICULTURAL RESEARCH

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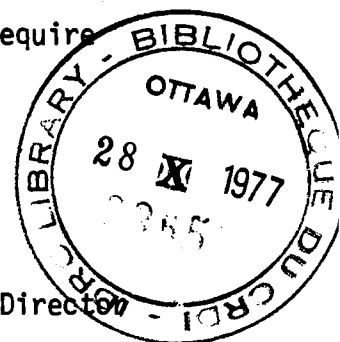
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The Food Problem

The events of the last few years and recent projections of future supply and demand leave little room for doubt that greater efforts will have to be made to increase food production in developing countries. A recent study by the International Food Policy Research Institute (IFPRI) of current world trends indicates that demand for cereal grains may exceed domestic production by 85 million tons in the developing countries by 1985-86. An aggregate figure such as this hides the especially serious problems faced by the low income food deficit countries. These countries, with a per capita income of less than \$200 per annum, include 60 percent of the population of all developing countries. The rate of growth in food production in these countries will have to increase from the present two percent to about four percent. Growth rates in middle income food deficit countries (GNP per capita of \$200-\$400) will have to increase from about three percent at present to between five and eight percent to meet projected demand levels. These rates of growth are higher than have ever been achieved in the past on a sustained basis. Any program to achieve these higher rates of growth in production will require a substantial increase in investment.

As part of this program, there will have to be increased

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investments in agricultural research. At the same time, greater efforts must be made to increase the effectiveness of agricultural research. The agricultural research and extension system in a number of developing countries is still an ineffective ally of the millions of small farmers who compose the largest proportion of the population and supply the bulk of total food production.

### Effectiveness and Utilization of Agricultural Research

In this paper we wish to discuss two forms of increased collaboration among scientists which are increasing the effectiveness and utilization of agricultural research. The first section deals with the development of interdisciplinary research programs based on an understanding of the farmer's resources and requirements. The second section deals with the increasing international collaboration among the scientific community concerned with agricultural development.

The small farmer operates in a highly complex environment in which the numerous interactions between factors such as the physical and agro-climatic and social and economic conditions, determine his level of food production. The farmer will adopt new technology only if it fits within the resources and constraints imposed by this environment.

The equally complex problem of developing productive new technologies requires a comprehensive systems approach employing the combined expertise of scientists from many disciplines. This does not lessen the contribution of the individual specialist in studying specific aspects of the farmer's system but requires scientists to collaborate in

designing and conducting their research programs. We believe the development of interdisciplinary cooperation among agricultural scientists has proven to be more effective in addressing the urgent problems of the small farmer than the traditional disciplinary approach. The International Agricultural Research Centers in particular have concentrated on establishing these multidisciplinary teams which focus on one particular problem or commodity.

The development of this research team approach has improved the ability of agricultural scientists to identify more of the factors and the interactions among these factors which influence and constrain small farm production. Research objectives can be based on the farmer's set of requirements and wishes.

### The Beneficiary

This aspect is especially important since we believe that "the beneficiary" still appears too rarely in non-industrial applied research projects and that applied research has little meaning if the beneficiary and the means by which the benefit is to be delivered are not clearly defined. It is fundamental to this approach that the beneficiary be consulted and that they contribute to the definition of objectives and the evaluation of results.

In this respect, it is instructive to note the paramount role assigned to consumer research in commercial enterprises. There are three essential components of any industrial enterprise: Marketing, Production and Finance. Marketing is primarily directed to satisfying a human

demand. It begins by determining first, who is making the demand, second, what product or service are they demanding, and third, how much are they prepared to pay for it. In commercial jargon, the first is called 'Market or Customer Identification' and the second and third 'Product Definition'. Thus, industrial research begins in the market place with the customer, not in the laboratory with the scientist.

The identification and requirements of the target customer and his environment is particularly important in developing countries since there may be considerable heterogeneity within a small region and the research team will have to tailor their program for each of these different environments.

#### On-Farm Testing

Relating the research program to the farmer's requirements and environment must be an on-going activity. While a considerable body of basic research information must usually be developed even before one can begin to develop technically feasible solutions, it is essential that research be conducted under typical on-farm conditions as soon as possible. The results achieved under the optimal conditions prevailing on most research stations may be considerably different from what is possible, given the sub-optimal conditions prevailing on most small farms. For example, weeding problems and labour requirements and availability are considerably different on a typical farm size unit than on a research plot.

Testing the response of farmers at an early stage not only helps

scientists to continually adjust their focus but also helps to ensure that the technological packages eventually developed are not so capital or management intensive that they aggravate the disparities in rural incomes. It is difficult to perceive farmer requirements beforehand and the target groups often use new technology in unexpected ways. Similarly, technological recommendations are rarely adopted in whole due to the low infrastructural support system prevailing in the rural areas of most developing countries.

### The Agricultural Economist

The agricultural economist and other rural social scientists have an important role as part of any interdisciplinary research team in identifying the farmer's objectives and economic and social constraints in the farmer's environment and then helping to define research objectives appropriate to these requirements. The agricultural economists' involvement with the farmer must go beyond testing the acceptability and benefits of specific research innovations. The farmer is influenced by a range of off-farm factors which influence his environment. The economist must determine the influence of these factors and identify and recommend possible changes. There is considerable evidence to indicate that critical bottlenecks elsewhere in the farmer's environment prevent his acceptance of more productive crop varieties or methods of farming. For example, one recent study carried out for IDRC on the post-harvest system in Africa provided evidence that even during the drought in the Sahelian region of Africa, there were farmers who could have produced more sorghum and millet if there had been adequate market outlets.

We have emphasized the role of the agricultural economist in particular because it has been our experience that in developing countries one of the primary problems in many applied research projects has been the failure to incorporate any economic research into the project. Related to this has been a tendency for the research project to be conceived, designed and executed in isolation from the potential beneficiary and the economic and social environment in which he functions.

We have often examined research proposals where the sole objective of the research program is to determine the technical feasibility of proposed new technology. The exclusion of any economic input is sometimes due to the narrow perception of the role of the economist by the scientists designing the project. Some scientists believe that new technology must be developed and proven technically viable before there is any point in bringing in an economist to consider its commercial feasibility.

More often, however, the problem is caused by the fact that many research institutions have no economists or other social scientists on staff or available to collaborate in a research project.

We have also seen projects where economists or other social scientists are associated with the research team but have restricted themselves to publishable studies on such topics as the structure of the industry while completely neglecting to undertake even a cursory analysis of the potential value of new technology developed in the project. His knowledge of the economic and social environment of the

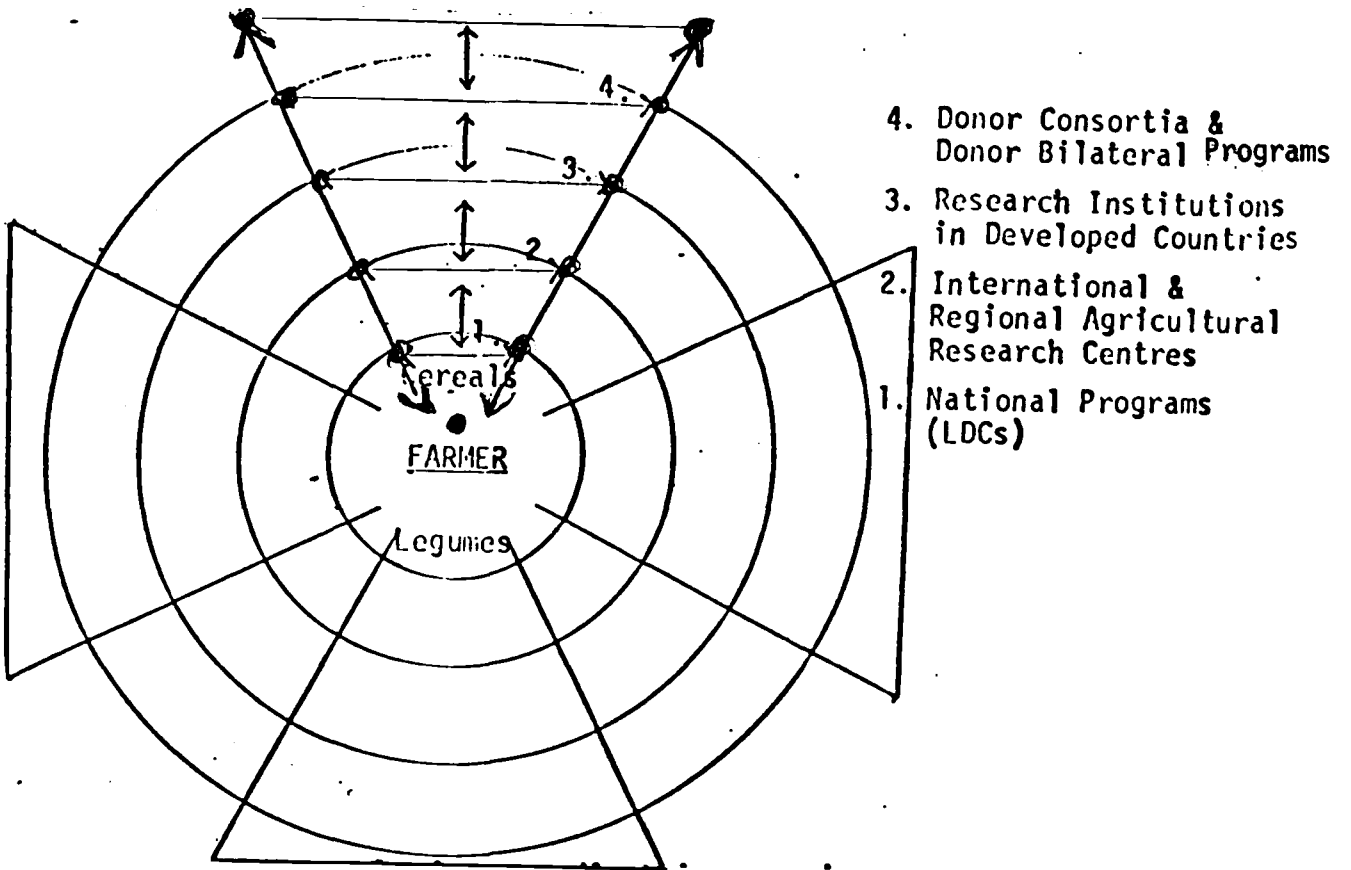
potential beneficiary is sometimes restricted to the data on survey questionnaires prepared for ill motivated and poorly trained assistants who do all the field work with the farmer.

### The International Research System

With the development of interdisciplinary research teams in national programs which are increasingly oriented to the total resource environment and requirements of the small farmer, we can be more confident that new technology will satisfy the aspirations and improve the well being of the rural community. Given the magnitude of the task involved, the research resources of a wider community of scientists than can be found in any national program must also be harnessed and efficiently coordinated.

Fortunately this has been happening and a research network is evolving which links scientists around the world in cooperative programs directed to solving the most urgent problems of tropical agriculture. This system links scientists in developing countries with regional research institutions, the International Agricultural Research Centers (IARCs), and developed country institutions in cooperative research programs. The recent development of more regional and International Agricultural Research Centers and their links to research institutions in developing and developed countries has created a "tripartite" system of agricultural research. Figure I provides a simple illustration of the links between these different groups of organizations and the supporting role of external donor agencies.

Figure I





These links are being developed by jointly agreed or collaborative research programs addressed to the same research problem. This collaboration is being promoted by an exchange of germ plasm, training programs and workshops, conferences and seminars.

### Developing Countries

While the number of agricultural scientists and annual expenditures on agricultural research are increasing in developing countries, as a whole they accounted for only 25 percent of the estimated level of global agricultural research expenditure in 1974.<sup>1</sup> Agricultural research expenditure as a percentage of the value of agricultural production is only about 1.2 percent in Africa compared to an average of 2.7 percent in North America.

At the same time it is interesting to note that, in addition to the shortage of financial resources in developing countries, there is evidence to indicate that a good proportion of agricultural research in the past has been in esoteric areas of little practical present or potential importance. One survey of resource allocation in India from 1938 to 1958, and from 1962-63 to 1965-66, determined that expenditure on wheat and rice research was extremely limited (less than 5%) whereas fruit and vegetable research received 18 percent of funds expended on agricultural research.<sup>2</sup> A recent IDRC publication, which listed all of

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<sup>1</sup> Boyce, J.K., and R.E. Evenson. "Agricultural Research and Extension Programs", Agricultural Development Council (ADC) New York, 1975.

<sup>2</sup> Rahman, A.T.R. "An Overview of Research Management in Southeast Asia" in "Institutionalizing Research Management in Asia", SEARCA, Philippines 1974.

the research projects of 56 food and nutrition sciences institutes in South and Southeast Asia, showed that less than 21 percent of the 651 research projects were on rice, fish processing or food legume processing, although the senior staff of these institutions had identified these three areas as the most important research problems of the region.

A number of developing countries have created national agricultural research institutes that group all the main research programs under one umbrella in an attempt to determine priorities and to create sufficient research expertise among different disciplines to tackle their most urgent research problems. The Indian Council of Agricultural Research (ICAR) with All-India Coordinated Research Programs for specific crops and the Malaysian Agricultural Research and Development Institute (MARDI) are examples of this approach. Some developing countries have made substantial progress in establishing a strong national research capability. This is an essential requirement since studies indicate that developing countries need to develop this research capability before they can draw upon and utilize research results from outside the country.

However, many of the institutions in developing countries lack the human or financial resources necessary to undertake all of the research required by their countries in any given area of agricultural activity. At the same time, several countries, particularly those in the same agro-climatic zone, exhibit similar conditions, opportunities and needs.

Developing countries have attempted to increase research on specific problems by establishing regional research centres or cooperative regional programs. The International Agricultural Research Centers have encouraged the establishment of a number of networks of cooperative national research programs.

IDRC has played a catalytic role in establishing a number of groups composed of scientists from developing countries who have undertaken the responsibility of establishing their own research priorities, and then, with IDRC financial support, defining and developing cooperative research programs based on these priorities. By bringing together, for example, all of the forestry research directors from the semi-arid countries of Africa, it has been possible to map out a comprehensive program of research that is of interest to a great many countries but which is more diverse and demanding of greater resources than any single country can provide. The directors of the individual project components are able to integrate their activities and communicate among themselves the results obtained and any difficulties encountered. In several instances, IDRC is providing a technical advisor or network coordinator who acts as a focal point for information exchange and technical advice and support.

#### Regional and International Agricultural Research Centers

National research programs are being supported by an increasing number of regional programs and International Agricultural Research Centers. Some examples of regional programs are the Office de la

Recherche Technique d'Outre-Mer (ORSTROM) in West Africa, the Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE) serving Central America and the Caribbean region and the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) in Southeast Asia. These organizations are generally supported by member governments from the region supplemented with external donor support. One of the newer regional organizations is the West Africa Rice Development Association (WARDA) which was founded by thirteen West African countries as a single commodity research and training program aimed at increasing rice production in the region.

One of the most positive developments in the last decade in increasing cooperative international agricultural research has been the establishment of the Consultative Group for International Agricultural Research (CGIAR) which has allowed the creation and joint donor financing of a number of new International Agricultural Research Centers (IARCs). The impetus for the establishment of the CGIAR and the new IARCs arose out of the International Agricultural Research Centers created by the Ford and Rockefeller Foundations in the 1960s.

Twenty-nine donor countries and agencies at present jointly finance the work of eleven IARCs and related programs. The establishment of these centres with a staff of more than 300 senior scientists, and more than 4,000 employees in total, has added a valuable new element to the "internationalization" of agricultural research. The international character of the centres provides them with access to an enormous range

of genetic material throughout the world. This greatly enhances their ability to breed a number of desirable characteristics into a single plant variety. The earlier emphasis of the centres towards purely biological research has been broadened to include farming system research for the small farmer and research on the social and economic constraints to increased production.

The international centres have developed cooperative networks linking their research programs to those of a number of individual developing countries. The centres have established library and documentation services on particular crops and organize conferences, seminars and workshops to link the scientists involved in each network. The centres have also expanded the number of research projects carried out in individual countries in collaboration with national programs with fully one quarter of the centres' budgets in 1975 being used for these collaborative programs. Links with developing countries are also strengthened by active training programs run by the centres. Over 3,000 scientists and production specialists have been trained in these centres to date.

Since joining as a charter member of the CGIAR, IDRC has played an active role in financial support of the centres and has been actively involved in the creation of three of the most recent centres. It is presently acting as the Executing Agency of the CGIAR for the establishment of the International Centre for Agricultural Research in Dry Areas (ICARDA) which will carry out research on the crops and cropping systems

of importance to the Near East and North Africa. IDRC's involvement with these centres has been directed primarily to strengthening the ties between the international centres and individual national programs by supporting cooperative research projects in developing country institutions which are part of the centre's commodity network.

#### Basic Research in Developed Countries

Neither developing countries nor the international centres have the resources or facilities to carry out or conduct the fundamental research on the scale necessary to achieve the long-term requirements for a sustained growth rate in food production of three percent to four percent in developing countries or such other objectives as a reduction in dependence on energy-intensive production inputs to achieve high crop yields. The extensive scientific and physical resources of the developed countries must be more effectively oriented to the basic problems limiting increases in agricultural production. The aid agencies and the International Agricultural Research Centers have taken advantage of these facilities in developed countries and are contracting out particular problems to organizations in these countries.

IDRC support for applied research projects has led to contracts to research institutions in Canada and other developed countries since every applied research project, or program, brings to light from time to time a problem which requires a more fundamental study. Two on-going examples of this type of project are the studies of the physiological

mechanism of tolerance to drought stress in sorghum at the Universities of Saskatchewan and Laval, and the production of disease-free cassava plants by tissue culture at the University of Guelph.

#### IDRC Supporting Services

Most of IDRC's financial resources are directed to networks of applied research projects in developing countries or to research programs in the regional and International Agricultural Research Centers, and developed country institutions which support these developing country research programs. However, IDRC also undertakes other activities in support of this cooperative research network. We have financed a number of general studies to determine the main characteristics, problems and potential of different neglected agricultural activities.

An example of this kind was a study on global cassava prospects undertaken by Dr. Truman Phillips from the University of Guelph to help determine priorities for the cassava research program being mounted by the Centro Internacional de Agricultura Tropical (CIAT) in Colombia. One of the results of this study was to point out the tremendous market for cassava as a high starch animal feed supplement in the European Economic Community (EEC). Demand for cassava for compound feed preparation in the EEC was expected to increase from between 246 to 634 percent between 1970 and 1980. This study provided support for the decision of scientists at CIAT and elsewhere to concentrate on increasing yields of cassava rather than trying to increase the low protein levels in cassava at the expense of yield.

We have also sponsored, sometimes jointly with other agencies, international expert Working Groups, some of which serve to identify important research programs and how they should be examined, to review progress in given projects or networks, or to bring together representatives of different international bodies, each of which can contribute to the better understanding of a common problem. An example of the latter case is IDRC's joint sponsorship with several international scientific unions and IARCs of a Working Group to define nutritional standards and methods of evaluation to be used in the guidance of cereal and legume breeders.

#### Cropping Systems Research

The Cropping Systems Research Network which has developed in South and Southeast Asia represents a functioning example of the interrelationships we have outlined above:

1. cooperation between international and national research programs;
2. an inter-disciplinary approach to agricultural research; and
3. research description, design and testing in association with the intended beneficiary - the farmer.

Research on increasing agricultural production has traditionally focused primarily on expanding the area and improving the yield of individual crops. Cropping systems research focuses on a third dimension, time, by attempting to increase the total annual yield per unit of land of time. Cropping systems research involves the cropping pattern as a variable in the quest for more efficient resource utilization. Whereas



farming systems research addresses itself to each of the enterprises present on the farm and the interrelationships between these enterprises, cropping systems research confines its activity to the crop production enterprise of the farm.

Specific types of cropping patterns which have been commonly practiced by farmers in most regions of the developing world are multiple cropping - defined as the growing of two or more crops consecutively in the same field in a single year - and intercropping - which involves two or more crops grown simultaneously on alternate rows on the same tract of land. Although these are common agricultural practices, there has not been much research on developing more scientific ways to exploit the superior features of the system. The opportunities for increasing annual yields substantially from cropping patterns became more evident after the widespread introduction of the new early maturing varieties of rice by the International Rice Research Institute (IRRI) in Asia. The use of these varieties allowed farmers with rainfed land to harvest their crops one or two months earlier. This gave the farmers sufficient extra time and moisture availability to plant a second crop.

Mounting a comprehensive research program on multiple cropping systems is beyond the resources of most research organizations since the process of systems research is complex, involving a combination of technical and social and economic variables which represent the managerial and environmental constraints which face the mixed cropping farmer. This includes variables in the environmental complex such as available

rainfall and irrigation, soil texture and toxicities, day length, solar radiation, temperature and the availability of resources such as labour, power and cash. Also involved in this matrix are management conditions which face the farmer such as the type and arrangement of crops in time and space.

The establishment of a cropping systems program at IRRI, closely linked to a number of cooperating national programs in the region, has overcome the following complications in cropping systems research:

1. cropping patterns are unique to agro-climatic and socio-economic environments and therefore, research must be undertaken at experimental sites which represent a variety of environments;
2. due to the complexity of the systems research, there is a need to have one common base to compile, analyze, develop methodologies and act as an information centre on cropping systems research; and
3. few national programs in developing countries have the "critical mass" of research resources to undertake a coordinated systems approach to all facets of cropping systems research.

IRRI has the scientific and organizational resources to help coordinate national programs and to help develop and define the research methodology and elucidate general principles. National institutions are able to conduct on-farm research at a large number of individual sites throughout the region. By 1976, the cropping systems network had grown to include institutions from six countries in the region working at fourteen different locations.

The activities of each project in the network are monitored by a

Working Group composed of project scientists from each of the participating countries, the IRRI program leader and an IRRI network coordinator along with two scientists from outside the region. The Working Group, which usually meets twice a year, has helped IRRI maintain a close relationship with each of the national programs and assisted in the formulation of guidelines on the direction of research and to evaluate and modify the program as experience dictates.

These ties have been strengthened by a major training program at IRRI for research and extension workers who return to their national cropping systems programs. A close relationship has developed between IRRI and the University of the Philippines at Los Banos (UPLB) which involves students taking their formal degree courses at UPLB and their thesis research on multiple cropping at IRRI under the supervision of senior IRRI staff.

UPLB also plays a major supporting role by conducting a varietal screening program for the region on upland crop varieties which can be grown in cropping patterns with rice.

Each of these research programs draws upon an interdisciplinary team of scientists. A wide range of disciplines such as agronomists, soil scientists, entomologists, economists, climatologists and pathologists are involved in this research. UPLB is building in this interdisciplinary team concept by encouraging M.Sc. students from various disciplines to work together on a common multiple cropping project. Upon completion of their research, the students submit a composite thesis to

the university.

Another important aspect of this program has been the emphasis on working closely with the farmer in the description, design and testing stages of cropping systems research. IRRI has attempted to ensure the relevancy and usefulness of their research by eliminating experimental research trials and conducting all research on farmers' fields under farmer management.

The results to date have been encouraging despite the complexity of cropping systems research. The superior yields possible with multiple cropping or intercropping patterns have been documented and proven by farmer response. In the lowland rice areas of the Philippines where soil problems are not limiting, it has been shown that two crops of direct seeded early maturing varieties of rice are possible. Farmers obtain yields that average from 7.0 to 10.2 tons per hectare from two rice crops. This compares to the local average yield of two to four tons per hectare. Intercropping corn with common upland rice is 30 percent to 40 percent more productive than monoculture due to the higher photosynthetic efficiency of corn during the early weeks of growth and the high efficiency of rice later in the growing season.

The research program in Thailand indicates that double and triple crop sequences in a year in different combinations can increase the annual gross income of farmers from 112 percent to 469 percent.

These research programs have also indicated that there is

considerable scope for changing farming practices to increase crop yields and profitability.

Experiments conducted on the red-yellow podzolic soils of Indonesia showed that modest levels of fertilizer and other inputs on intercropping patterns resulted in more than a doubling of the net return in income per hectare. Increasing the number of crops planted per year may be possible by reducing the turnaround time (the time between harvesting of one crop and planting of the next). While rainfall is a major factor in determining turnaround time, Indonesian data indicates that a shift from paddy rice to an upland crop requires only  $18 \pm 7$  days whereas the conversion from upland crops to paddy rice takes  $53 \pm 15$  days. Problems with pests are considerably less when corn is seeded after rice than when corn is seeded before rice.

Variation in cash income appears to be an important determinant of farmer behaviour. An IRRI study of weekly cash flows in the Philippines showed that financial linkages among the farmer's crop, livestock and household needs are important. For example, a farmer will often sell his livestock at planting time to buy crop inputs.

Labour, rather than land, availability appears to be the binding constraint in the farmer's cropping system. IRRI research at the Batangos outreach site in the Philippines indicated that farming intensity is influenced by labour availability but not by farm size (ranging from 0.5 to 2.5 hectares).

Farmer response to more intensive experimental cropping systems has been encouraging. Scientists at UPLB have been evaluating the ability of rural communities to sustain the accelerated rates of production resulting from an intensive cropping systems program developed in association with IRRI. Some twenty-four villages representing various agricultural production systems were originally selected, some of which are now functioning independently. The success of the program is evidenced by the increased number of farmers undertaking multiple cropping. On average, the percentage of land double-cropped in the original project villages has doubled and the number of participating farmers has risen from 29 to 490. The number of farmers borrowing credit in the village banks rose by 800 percent in two years as the program began to take effect.

While this cropping systems research is still relatively new, the progress already achieved is a good indication of the benefits to be derived from cooperation among interdisciplinary groups of scientists from different countries, each national team working closely with the small farmers of that country.