Approaches to On-farm Research in Asia

International Crops Research Institute for the Semi-Arid Tropics

Abstract

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On-farm adaptive research is an important component of agricultural research that attempts to adapt technology to suit farmers' conditions. A regional workshop in Vietnam brought together representatives of 13 member countries of the UNDP/FAO RAS/89/040 Project and from regional and international institutions in Asia, to exchange knowledge on on-farm research. Papers presented at the workshop include case studies from the Asian Grain Legumes On-farm Research Project countries, status reports on on-farm research and methodologies followed by different countries, and experiences of regional institutions working in Asia. Recommendations from the participants' discussions include suggestions for methodologies of on-farm research that involve farmer-participatory approaches.

Résumé

Méthodes d'approche à la recherche en milieu réel en Asie: comptes rendus de l'Atelier régional sur la recherche adaptive en milieu réel, 18-20 février 1993, Ho Chi Minh ville, Vietnam. **La recherche adaptive qui vise à adapter les résultats de la recherche au milieu rural constitue une importante composante de la recherche agricole. Un atelier régional a réuni des représentants de 13 pays membres du Projet PNUD/FAO RAS/89/040 ainsi que des instituts régionaux et internationaux en Asie afin de faire le point des connaissances actuelles sur la recherche en milieu réel. Les communications présentées lors de l'atelier traitent des études de cas des pays du Projet asiatique de la recherche en milieu réel sur des légumineuses à grains, des rapports des différents pays et des méthodologies suivies par eux ainsi que l'expérience dans ce domaine des instituts oeuvrant en Asie. Les recommandations formulées à partir des discussions des participants comprennent des suggestions pour des méthodologies qui mettent l'accent sur la participation des agriculteurs dans la recherche en milieu réel.**

Cover: Vietnamese women farmers sowing pregerminated groundnut seeds.

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Summary Proceedings of the Regional Workshop on On-farm Adaptive Research

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Ho Chi Minh City, Vietnam

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International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

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Inaugural Session

Welcome Address

Ngo The Dan[1]

On behalf of the Organizing Committee and the Ministry of Agriculture and Food Industry, Vietnam, I would like to extend to all of you a very warm welcome to this Regional Workshop on On-farm Adaptive Research, which is being held immediately after the study tours in Nepal and Vietnam.

Vietnam is one of the four Asian Grain Legumes On-farm Research (AGLOR) project countries under the UNDP/FAO RAS/89/040 project on Improvement of Food Legumes and Coarse Grains in Asia. In Vietnam we are implementing an on-farm research project on groundnut, the most important legume and cash crop in our country. Under this project, for the first time in Vietnam, key constraints to groundnut production have been identified, and a plan for on-farm experiments to address these constraints is being implemented. Initial results of these experiments are encouraging. It is a great honor for us to host the study tour and this workshop. We are sure that through our discussions in this "workshop we can learn from your experiences, and that we can successfully implement the AGLOR Project, which not only has the potential to improve groundnut but also to improve other food legumes and coarse grains in our country.

On this occasion, we would like to express our sincere thanks to RAS/89/040, the donor agencies, the Regional Coordination Centre for Research and Development of Coarse Grains, Pulses, Roots, and Tuber Crops of the Economic and Social Commission for Asia and the Pacific (ESCAP CGPRT), and ICRISAT scientists for their efforts and cooperation in supporting the AGLOR Program in Vietnam. We are very grateful to the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Development Programme (UNDP) offices in Hanoi, the Regional Coordinator of RAS/89/040, the Cereals and Legumes Asia Network (CLAN) of ICRISAT, and other scientists who have made great efforts in organizing this workshop. We are grateful to all of you for attending this meeting and visiting Vietnam.

Once again let me extend a hearty welcome to you, along with best wishes for a successful meeting.

1. Vice-Minister, Ministry of Agriculture and Food Industry, Hanoi, Vietnam.

Objectives of the Workshop

Dewa Made Tantera[1]

I would like to welcome all of you to this workshop organized in Ho Chi Minh City. The workshop had been planned at the third Regional Coordination Committee Meeting held in Korea, Jun 1992. Vietnam agreed to host the workshop, which has materialized today through the able leadership of Dr Ngo The Dan, Vice-Minister, Ministry of Agriculture and Food Industry, and RAS/89/040 National Coordinator for Vietnam, for which we are all grateful.

The organization of this workshop has also involved ICRISAT in the technical planning and the Regional Coordination Centre for Research and Development of Coarse Grains, Pulses, Roots, and Tuber Crops of the Economic and Social Commission for Asia and the Pacific (ESCAP CGPRT) in the design of the workshop program as on-farm research requires the generation of technology as well as a study of socioeconomic aspects. Hence, the combined effort of RAS/89/040 and the two centers have helped in promoting food legumes and coarse grains in Asia.

The workshop was organized in tandem with a study tour on On-farm Trials in Nepal (8-12 Feb) and Vietnam (15-17 Feb). This study tour was organized prior to the workshop to provide field experience to participants so as to have a common basis for interaction during the discussions. During the 5-day tour in Nepal, the participants visited on-farm trials on chickpea and pigeonpea in Sarlahi district (central Nepal) and in Banke and Bardia districts (western Nepal). In Vietnam, they visited groundnut on-farm trials in Go Dau, Trang Bang, and Duc Hoa districts. The participants interacted with researchers, extension staff, and farmers who were involved in on-farm research to gain first-hand information on planning and conduct of trials and farmers' reactions on the usefulness of trials. Four theme groups were formed and members in each group collected data and information relevant to their themes.

The objectives of the workshop are:

- To discuss the methodologies and techniques of on-farm adaptive research for food legumes and coarse grains (FLCG),
- To review and discuss the results of the Asian Grain Legumes On-farm Research (AGLOR) project; and
- To prepare plans for on-farm adaptive research in member countries of RAS/89/040 project for increasing production of FLCG crops in Asia.

Regional Coordinator, UNDP/FAO RAS/89/040, Bogor, Indonesia.

The country representatives at the workshop are knowledgeable in on-farm research conducted in their national programs. They will share and discuss their experience which, I hope, will benefit everyone. The workshop organizers have invited resource persons from institutions in Asia involved in on-farm research so that they can share their knowledge with the other participants.

The attendance at this workshop has been more than we had anticipated. All the member countries and institutes invited have responded either through their staff representation or by sending papers. I am particularly happy to note the attendance of administrators and donor agency representatives, in particular Drs Y.L. Nene of ICRISAT, Dimyati Nangju of the Asian Development Bank, and Narong Chomchalow of the FAO Regional Office for Asia and Pacific.

The theme of this workshop is on-farm research and technology transfer. The workshop will examine the utilization of on-farm research in the identification of technology options for adaptation and adoption by farmers in a given area. Our previous experience has indicated that there are many pitfalls in the practice of on-farm research: lack of understanding of farmers' problems and perceptions on the part of the scientists and administrators; and on-farm research for the sake of research, without any conclusive evidence of adoption. So we need to refine on-farm research methodologies to ensure that the results are beneficial to poor farmers. This will be evident only if the technology is adopted, wholly or partially, by the farmers. I consider that nonadoption of technologies is a failure of on-farm research. This workshop will try to evaluate the reasons for such failures, if any.

Adoption of technology involves communication between research, extension service, and farmers. This linkage should be forged through on-farm research. One of the major limitations of the on-farm research process is its location specificity. Therefore the validity of a package of recommendations for a large area is not realistic. Research efforts and technology testing should address and meet the needs of specific locations.

Let us hope that the discussions in this workshop will bring further understanding and actual progress in the development of on-farm research procedures.

Inaugural Address

Nguyen Van Huan[1]

It is a great honor for me, on behalf of Ho Chi Minh City Peoples' Committee, to extend a hearty welcome to the participants from different countries of Asia, international and regional organizations, and from different regions of our country, who are taking part in the Regional Workshop on On-farm Adaptive Research. In Vietnam, maize and legumes are very important crops after rice. These crops provide food for human beings and feed for poultry and livestock. Some are also cash crops for earning foreign exchange. In 1992, Vietnam obtained a bumper harvest of rice, maize, and legumes. Compared with 1991, grain production increased by 9% and reached 24 million tonnes. Analyzing the main reasons for the success in agricultural production in 1992, our government realized that, along with favorable weather conditions, the Vietnamese farmers have profited from new management techniques. The shift from a centrally controlled economy to a market economy, and the change from cooperative and state farm management to the farmer household as an independent production unit have also contributed to increased agricultural production. Farmers now have the right to use land on a long-term basis and to make appropriate production and marketing decisions by themselves. They have to pay only land tax to the government. Due to this new economic policy, the potentials of the labor force and land for production have been mobilized.

Farmers have become interested in their land and their own achievements. Transfer of new technology to the grass-root level needs to be encouraged. Therefore, the objectives of this workshop are very attractive. On-farm adaptive research will be a bridge between technology and production, and thus encourage agricultural development.

I would like to express my sincere appreciation to all of you and I hope that this is also a good opportunity for you to come to our country to see with your eyes the changing scenario of Vietnam and to understand more about our people in general, and Ho Chi Minh City in particular. I offer my best wishes for a successful meeting.

1. President, Ho Chi Minh City Peoples' Committee, Vietnam.

On-Farm Adaptive Research and Technology Exchange

Y.L Nene[1]

Introduction

On-farm adaptive research (OFAR) is a link between the laboratory or on-station research and the actual acceptance of proven technologies by farmers. OFAR is like the research carried out by an industrial concern to successfully get its product accepted by customers or consumers. In this process, just as both the manufacturers and the customers are benefitted, in the case of successful OFAR, both the scientists and farmers are benefitted. Customers and farmers are 'always right' and therefore the extent of acceptance/adoption of a product/technology is a measure of success. Just as the industry's research and development activities relate to products designed for customers of different economic strata, OFAR also has to relate to farmers of various strata, i.e., marginal (very small), small, medium, medium-large, and large farmers depending upon the size of their holdings and other assets at their disposal. In most cases, the economic level of farmers determines their capacity to muster resources. Of course, we must remember that a 'large' farmer in a densely populated, agriculture-dependent country, belonging to the old world could be classified as a 'small' farmer in the new world. The usual size of farms is generally small in the old world, especially in Asia. Some technologies can be adopted in full only by large farmers, but individual, high benefit-cost ratio components of such technologies can be adopted by small farmers with limited financial resources. It is best that we expose farmers to a complete set of technologies and let them decide whether they should take all or only parts of it.

We must remember some special features of the farmers of Asia. Asia represents the old world with a very long history of farming. There is practical wisdom accumulated over many centuries, and therefore, it would be unwise to treat such farmers as 'backward' or ignorant. No one should make the mistake of assuming that the knowledge base of these farmers is limited. We must also remember that in most Asian countries, the cropping systems are based on rice and/or wheat. Other crops, such as coarse cereals, legumes, oilseeds, etc., have to fit into rice- or wheat-based cropping systems.

It is often said, and rightly so, that seeing is believing. Results of OFAR have to be seen and approved by farmers and their families. We must not underestimate the role of the women in influencing the decision-making process. Farmers' participation in OFAR will provide an interactive mode so that both the researcher and farmer can decide on the conduct of trials, and technology to be tested. Active participation of farmers in the conduct of OFAR improves the chances of its success.

1. Deputy Director General, ICRISAT Center, Patancheru, Andhra Pradesh 502 324, India.

Prerequisites for the Success of a New Technology

There are a few important prerequisites essential for the successful adoption of a new technology via OFAR. Some of these are described below:

Site Description

A prerequisite for undertaking OFAR in any given area is a description of the site. We must know as many details as possible about the target area where OFAR is to be conducted: about the soil (physical, chemical, and biological properties of the soil), climate (temperature, solar radiation, relative humidity, and rainfall pattern), and the common cropping systems. Information on irrigation availability, economic status of the target farmers, social environment, level of farmers' formal education, and political environment is essential. Other knowledge required includes information on road and rail infrastructure, relations between the community of the region and government departments, and nongovernmental organizations (NGOs), and between government officials and NGOs, and the role of rural leaders in the target area. The more we know about all of these aspects, the better prepared we will be to embark on OFAR.

Research Staff

The research staff responsible for OFAR should be fully dedicated, experienced, competent, enthusiastic, genuinely concerned (not just sympathetic) about farmers' welfare, and prepared to listen to farmers with respect. They should also be believers in action, flexible in their attitudes, resourceful, and innovative. It may not be always possible to get such persons. However, chances of success would increase if the research staff possess many of these characteristics, if not all.

Training of Participants

Not only the research staff but also other participants such as the extension and support staff and farmers, should all be fully familiar with the principles and practices of the basic ingredients of the technology.

On-farm Validation Trials

Once the research part is complete, the technology should be tested on farmers' fields with farmers sharing the responsibility. Failure at this stage would be most unfortunate, and therefore, no stone should be left unturned in achieving success in these on-farm validation trials. For OFAR and for on-farm validation trials, selection of farmers is very important. Farmers must be willing partners who are as much interested in achieving success as the researchers themselves. They must have the required physical facilities and must not be addicted to subsidies.

Common Goal

Multidisciplinary research teams must work together with a common purpose. They must understand the problems together and seek solutions as a group. Again, there should be no hesitation in consulting support staff, farmers, or NGOs.

Monitoring of Trials

Monitoring is absolutely essential for the success of OFAR. Periodic monitoring enables the participants to undertake corrective actions in time. It is better to abandon the trials if factors beyond control have affected them adversely. Frequent monitoring increases interaction between partners, and keeps their interest alive.

Spreading the Message

Successful OFAR trials are excellent tools for spreading messages about new technologies. Word gets around and neighboring farmers visit these trials even without any formal invitation. Organizing visits of farmers, extension workers, politicians, policy makers, and bureaucrats is worthwhile. Detailed descriptions of these trials should be prepared for distribution. On-farm question-answer sessions for visiting farmers should be organized to gain insight by both researchers and farmers. If the seed of a new cultivar is an important component of the technology, steps should be taken to multiply it quickly so as to be able to meet the demands of interested farmers.

Economic Evaluation

Ultimately, farmers will be interested in knowing about the cost of the new technology and the extent of benefits that they would get. It is important to carry out an economic evaluation of the complete technology as well as of the significant individual components.

Impact Assessment

After the new technology is adopted by farmers of a region, it is important that the real impact of the technology on the whole community (farming and non-farming) is assessed.

Reasons for Slow Adoption of Technologies

There may be several reasons for not adopting improved technology (Brady 1981; Gowda et al. 1993). But, there are also some myths about the reasons for the failure of technology adoption which are not true.

- **Farmers resist change.** In fact, farmers do not resist change. They know what is best for them and adopt a practice that enables them to earn more benefits, either monetary or nonmonetary. They often adapt technologies to suit their needs. When ICRISAT introduced the broadbed and furrow (BBF) system for better soil-water management in groundnut cultivations, farmers in India used the furrows as irrigation channels and reduced the width of broadbeds from 1.2 m to 0.75 m to ensure movement of water to the center of the broadbeds in some soil types. If farmers do not adopt a technology, it is certainly not due to their alleged resistance to change.

- **Extension services are not effective.** In some countries extension services may not be effective. However, this is frequently due to lack of full support to extension workers. If politicians, bureaucrats, and researchers extend strong support, extension workers will not fail. Often we see that the extension workers belonging to NGOs or private companies do their job effectively.

- **Inputs are unreliable or not available.** Timely availability of inputs at reasonable cost is critical to the success of technology adoption. Getting standard-quality inputs can be a real problem in some countries. Strict laws monitoring the quality of purchased inputs and severe punishments to offenders are necessary to eliminate the evil of substandard quality inputs. Once convinced of the advantage of purchased inputs, farmers do not hesitate in buying them. In the late 1960s, when the commercial grade of zinc sulphate was not available to control the *khaira* disease (zinc deficiency) of rice in north India, farmers bought the chemical grade of zinc sulphate at much higher prices.

- **Lack of credit.** This is a real problem in some countries, but in recent years governments of many countries have intervened to provide low-cost credits to farmers.

- **Technology not applicable to actual farmers'** conditions. This happens only when farmers are not participating in the effort. Also a technology might be adopted by large or medium-level farmers, but not by small farmers, as the latter may find it beyond their means.

Why Did ICRISAT's LEGOFTEN Program Succeed in India?

In 1987, India imported edible oil costing over US$ 1 billion. As groundnut is an ICRISAT mandate crop and groundnut oil an important edible oil, that year the Government of India invited ICRISAT to assist in its efforts to increase groundnut production. In cooperation with the research and extension staff and farmers in several states of India, ICRISAT scientists of the Legumes On-Farm Testing and Nursery (LEGOFTEN) Unit demonstrated that improved technology could give up to three times the average district yields under both rainfed and irrigated conditions. In farmers' field trials over a 3-year period, using an improved high-yielding ICRISAT variety gave a 32% yield increase, and improved crop management gave a 25% increase. The two inputs when combined gave a 50-150% increase. Since then, improved packages have been adopted by farmers on a large scale (McDonald et al. 1992).

Among the reasons for the success of the LEGOFTEN program are:

- the Government of India was genuinely concerned about the high edible oil import bill;
- ICRISAT scientists were regularly reporting groundnut yields of 4-6 t ha^{-1} in experimental fields. These were considerably higher than average yields obtained by farmers (0.8 t ha^{-1} under rainfed conditions and 1.7 t ha^{-1} under irrigated conditions);
- market prices for groundnut became favorable to farmers;
- participants were experienced research scientists, qualified extension workers who were given intensive training at ICRISAT Center, and enthusiastic farmers who were prepared to try new technologies;
- frequent monitoring of OFAR trials by ICRISAT scientists was undertaken and corrective actions were taken in time. Mismanaged trials (40% in the first year) were quickly abandoned;
- sufficient seed of improved cultivars was available to farmers;
- field days were organized; farmers, politicians, extension workers, bureaucrats, seed growers, state agricultural university officers and scientists, journalists, radio and TV personnel were all invited. The message spread rapidly.

Conclusion

I have covered several issues concerning successful on-farm adaptive research and technology transfer. By no means is this coverage complete; several more issues can be raised and discussed. However, the basic truth is that the success in technology transfer is directly proportional to the positive will of the governments, interested NGOs, concerned scientists and extension workers of both public and private sectors, and of course the farmers themselves.

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Background Papers

On-farm Research: Planning and Implementation

C.L.L. Gowda, S.N. Nigam, D.G. Faris, and D. McDonald[1]

Introduction

Technology transfer to increase productivity and production was successful in the green revolution era in the highly productive and homogeneous areas called 'core areas'. However, the adoption of technologies has been slow in the more diverse, less productive and heterogeneous 'hinterlands'; because technologies designed for 'core areas' cannot be applied to the 'hinterlands' (Rambo and Sajise 1985). In the 1960s and 1970s, the top-down approach of technology transfer was successful in the more fertile and homogeneous areas, but not in the diverse, less-productive, and risk-prone areas (Chambers and Jiggins 1986). The earlier contention that farmers in these areas were ignorant and not willing to adopt new technology has been effectively challenged. It was considered that the problem was neither the farmer nor the farm, but the technology itself and the process of generating it (Chambers et al. 1989). Over the last decade, several scientists and groups have worked on various on-farm research (OFR) projects. These are too diverse and numerous to list here, but they can be grouped under such titles as: on-farm research; on-farm adaptive research; on-farm client-oriented research; and farmer-first-farmer-last approach. These have led to testing of technologies in the farmers' fields using a farming systems research approach, which in turn has led to an increasing acceptance of problem-oriented approach to planning agriculture research (Tripp and Woolley 1989). These are generally referred to as on-farm research.

On-farm research involves adaptation and/or adoption of technologies to suit the conditions in a given location with active participation from farmers Farmers themselves experiment constantly using the resources available to them, borrowing ideas from neighboring farmers and adopting those ideas, technologies, and cultivars (Knight 1974). According to Tripp (1991), the hallmark of OFR is its location-specific approach which takes the conditions and priorities of a particular group of farmers as the starting point for planning and executing an adaptive research program.

1. ICRISAT Center, Patancheru, Andhra Pradesh 502 324, India.

OFR can be used for developing different types of technology: technologies that improve the efficiency of crop management, those that require significant changes in farming systems (Tripp 1991), and those that depend on single components (such as crop varieties) that can have a tremendous effect on both crop management and farming systems.

Farmers have been increasingly recognized as sources of indigenous knowledge and technology. Since many farmers do experiment themselves, advantage should be taken of their technical knowledge and experimental abilities in planning OFR, evaluation of technical alternatives, and adaptation of technologies to local circumstances (Fujisaka 1989). However, a realistic view is that both experts (scientists) and local people (farmers) have unique areas of expertise which collectively provide a better basis for development than either of them working alone (Raintree and Hoskins 1988). A recent book by Tripp (1991) gives a full perspective of OFR philosophy, methods, and various case studies. In this paper, we describe the project undertaken by ICRISAT in collaboration with four Asian countries under the UNDP/FAO funding.

Asian Grain Legumes On-farm Research

The Asian Grain Legumes On-farm Research (AGLOR) is one of the three components of the UNDP/FAO RAS/89/040 Project on Improvement of Food Legumes and Coarse Grains in Asia. The ICRISAT component of the project is entitled The testing and adoption of technology for increased and stabilized groundnut, pigeonpea, and chickpea production in South and Southeast Asia'. The activities of this component are in Indonesia, Nepal, Sri Lanka, and Vietnam. It was envisaged in the project document that the methodologies and results emanating from these four project countries will be shared with all the 14 member countries under the FAO RAS/89/040 Project.

The objectives of the project are:

- To assist national agricultural research systems (NARS) to assemble available information from research and extension sources within the project countries and the region that could be used in generating production technologies,
- To generate and test crop production technology under research station and farmers' field situations,
- To modify the most effective production technologies to suit real farm situations, and
- To enhance the adaptive research capabilities and interest of NARS in legumes production.

Review and Planning Meetings

Review and Planning Meetings were held in each of the project countries as a prelude to initiating the project activities. These meetings were organized by the concerned national program. The participants in these meetings included national program research administrators, scientists, extension staff, and ICRISAT scientists. The main purposes of these meetings were to review the existing information, document the available technologies, and decide on the target areas to undertake on-farm research. In Sri Lanka, a diagnostic survey was conducted first, followed by a planning meeting. In Indonesia, Nepal, and Vietnam, review meetings preceded diagnostic surveys, which were followed by planning meetings.

Diagnostic Surveys

Within each country, at least two major target areas of production were selected. It was essential to collate information on agroclimates and cultivation practices and to identify the production constraints, in each of these distinct target areas.

Special multidisciplinary teams were formed in each country, comprising scientists from the national program and ICRISAT. Two scientists from the International Rice Research Institute (IRRI) also assisted in the first diagnostic survey in Indonesia. The teams conducted diagnostic surveys using rapid rural appraisal methods. They visited the target areas and interviewed the village leaders and farmers using an informal approach. The main objectives of the survey were to become acquainted with the local farming practices and agroecosystems, agronomic and crop management practices, and to identify the reasons for low yield. A questionnaire (Table 1) was given, but the team members were free to modify the questions according to the situation. The group met for discussion each evening to synthesize the survey findings.

Table 1. A sample questionnaire used during the diagnostic surveys to identify production constraints.

- What is the total area in the village?
- How much of it is cultivated? (Farmer classification of land types.)
- What crops are grown in each soil type and why?
- How much land does the farmer own/cultivate?
- What is the cost of cultivation for a parcel of land, hectare or any local unit?
- What is the status of labor availabilities for crop management?
- What is the status of land accessibility—land owner, landless labor, etc.?
- What are the reasons for low yield?
- What are the environmental and biological factors for low/unstable yields?
- What are farmers' solutions/suggestions to overcome constraints to production?
- What are the major agroecologies in each village?
- What varieties are cultivated? What are farmers' preferences?
- How are crops, haulms, seed, etc., utilized?

Constraint Identification and Prioritization

Based on the information gathered during the rapid rural appraisal the scientists identified the farmer-perceived constraints and prioritized them according to the spatial and temporal occurrence of each problem and the extent of yield loss caused. The constraints were grouped into socioeconomic, biotic, and abiotic constraints. Suggestions were made to the concerned local administrative units and governments to address the socioeconomic constraints. Production constraints for a crop differed in the two target areas within a country. For example, major problems for the groundnut crop in northern Vietnam were, lack of money to buy inputs, wilt complex and damping-off diseases, and white grub damage; while those of southern Vietnam were lack of money to buy inputs, leaf-feeding insects, lack of high-yielding varieties, and of coconut ash for use as manure. Thus it was clear that each area surveyed needed different sets of experiments and technologies to alleviate the identified constraints. On the other hand, some problems such as pod borers, plant mortality, and lack of high- yielding varieties were common to both chickpea and pigeonpea crops across the whole of Nepal.

Planning of Experiments

Once the production constraints were identified and prioritized, the joint team of scientists planned experiments to address and alleviate the constraints. These were based on the nature of the problem and the availability of solutions and technologies within the country, region, or at ICRISAT. Research options were grouped as: (1) backup or supportive research that needs to be carried out, mostly on station, to find answers or provide solutions prior to taking these on farm, and (2) on-farm research where the scientists had available technology for direct testing. The extent of backup and supportive research varied among the countries according to the available technology base. In Vietnam, for example, the backup research included: (1) identifying the causal organisms responsible for the damping-off disease and wilt complex, (2) finding alternatives to coconut ash application, and (3) studying feasibility and profitability of growing a single crop of 140-day varieties instead of two crops of 90-day varieties in the groundnut-groundnut-other crops rotation.

The type of on-farm trials varied across the project countries. In Indonesia, the national program scientists were able to prepare a set of improved technology packages that could be tested directly in farmers' fields. These improved practices were compared with the farmers' cultivation practices. In Nepal, the survey team decided to evaluate single factors (plus and minus) in diagnostic experiments to evaluate and demonstrate the effect of individual technology options.

Conduct of Trials, Monitoring, and Follow-up Surveys

The national program scientists, along with extension staff and farmers in the area, managed the trials. Interaction with farmers was a key element. The trials were regularly monitored by the concerned scientists in each country. A joint monitoring of trials was undertaken by a team of scientists from the country and ICRISAT in each crop season to provide technical backup to field staff, to get feedback from farmers, and to suggest any mid-term corrections. In some countries, follow-up surveys were conducted during the monitoring period to better understand problems at critical stages, and to reassess the research priorities for the region. For example, the follow-up survey in East Java indicated that foliar diseases of groundnut were more important than insect pests, while during the initial survey farmers had indicated pests as being the major problems.

Review and Future Planning

Results of the trials were reviewed after each season/year in a joint meeting of national program and ICRISAT scientists. Based on the results obtained and the feedback from farmers and extension staff, the plans for on-farm trials were modified. In Indonesia the original set of three levels of improved packages (low, medium, and high-input) were reduced to two levels (low and high-input) after the first season because farmers indicated that the three levels were confusing.

In countries where single factor diagnostic trials were conducted, the individual treatment factors showing yield advantages were combined into a set of improved practices to be compared with the farmers' practices during the next season.

Conclusion

It has been a good learning experience for both national program and ICRISAT scientists, and we now have a better understanding of the problems affecting ICRISAT mandate legumes in the project countries. There has been increased interaction between research and extension staff in each country. The national program administrators have begun to address farmers' problems in a more realistic manner. The overall progress in the execution of the AGLOR project has been satisfactory. There were initial difficulties in some countries due to lack of trained staff to undertake the project activities, but this was overcome as some people were trained in OFR methodologies during the project implementation.

The backup on-station research and long-term research programs were strengthened to provide a more effective research base to support OFR activities.

Acknowledgements

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Technology Adoption and Economic Assessment of On-farm Adaptive Research

Ma. Cynthia S. Bantilan[1]

Introduction

On-farm adaptive research (OFAR) strategy targets its impact on farmers' fields. It ensures that farmers' points of view (including an understanding of farmers' conditions and problems, their priorities, and their criteria in adopting or rejecting new technologies) are represented in the research agenda.

OFAR introduces a package of technology or components of a package (e.g., new variety, equipment, cultural practices or techniques that result in more productive and better quality crops) or information including those that facilitate the acceptability and adoption of these technologies. The impact or potential impact of research effort is evaluated in terms of the extent to which welfare gains are achieved by farmers and other sectors of society.

The long-term and dynamic nature of OFAR demands mechanisms for periodic and systematic evaluation. Assessments are undertaken ex-ante (during research planning) to evaluate potential benefits; and ex-post (after research) to assess adoption and impact. During project implementation, a combination of ex-post and ex-ante assessment is useful to monitor refinements in research implementation and technology development. As in any other investment, planned assessments are important to rationalize choices among alternative research options and to provide a stronger basis for accountability and for decisions on research resource allocation.

This paper presents a general framework for agricultural research evaluation. This framework is discussed in the context of OFAR, featuring the key role of product acceptability and technology adoption. Two general approaches of measuring impact are described. A list of information variables (including technical and economic data) required for impact assessment is presented, citing some examples.

General Framework for Research Evaluation

Three main phases characterize the general framework for research evaluation. The framework starts with the consideration of research investments that fund the imple-

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mentation of research projects (Phase 1). The new knowledge and technology generated are expected to bring forth changes in the production and the consumption environment (Phase 2) as more and better commodities become available in the market as a result of the utilization of the new technology. To be more specific, the application of science-based technologies in agriculture is expected to bring about increases in crop yields, more palatable grains, bigger seed size, higher fodder yield, increase in average daily weight gain of poultry, and higher average litter size of livestock. Research is also expected to improve the efficiency of various inputs including management. Ultimately, the above changes in the production and consumption environment translate into increased welfare of the society (Phase 3).

Before the benefits of research ultimately accrue to the members of society (i.e., producers and consumers), three important conditions must be met. First, the research undertaken must be successful in achieving its targeted objectives. This introduces the notion of probability of success or relative research capability. Second, the potential increase in production promised by a new technology is ultimately achieved only when the technology is adopted by farmers. This condition necessitates the consideration of the rates of technology adoption and the factors constraining it. Third, the measurement of the welfare gain to society is incomplete if it does not take into account the externalities (both positive and negative) which the technology involves. This paper focuses on the critical role of the second condition (i.e. adoption) in achieving welfare change of the researchers' ultimate clientele — society. The first and third conditions have been considered in detail by Bantilan and Davis (1991a, 1991b).

Consideration of research evaluation in the context of OFAR provides an opportunity to feature the adoption phase as this type of research primarily aims to (1) improve the acceptability of technologies; and (2) facilitate the adoption of technologies. In this case, the following adoption-related variables are highlighted: adoption lags, rate of adoption, and ceiling level of adoption.

A typical adoption curve is given in Figure 1. Introduction of a new technology is not usually met by immediate adoption. The gestation period between the generation of a technology and its adoption varies by sector, commodity, and even types of technologies. There are farmers who adopt technology almost immediately while other farmers have a wait-and-see attitude and adopt only after the effects have been convincingly demonstrated. Reluctance among farmers to adopt a technology may be due to market uncertainty, price fluctuations, preference for specific grain qualities (e.g., large seed size), preference for very low management crop technology, etc. Thus, a sigmoid adoption curve is usually used to illustrate the adoption process where level of adoption is initially low, rises at an increasing rate after some sufficient diffusion is attained, and finally reaches a ceiling level of adoption. Adoption lag refers to the time interval between introduction of technology to attainment of the ceiling level of adoption.

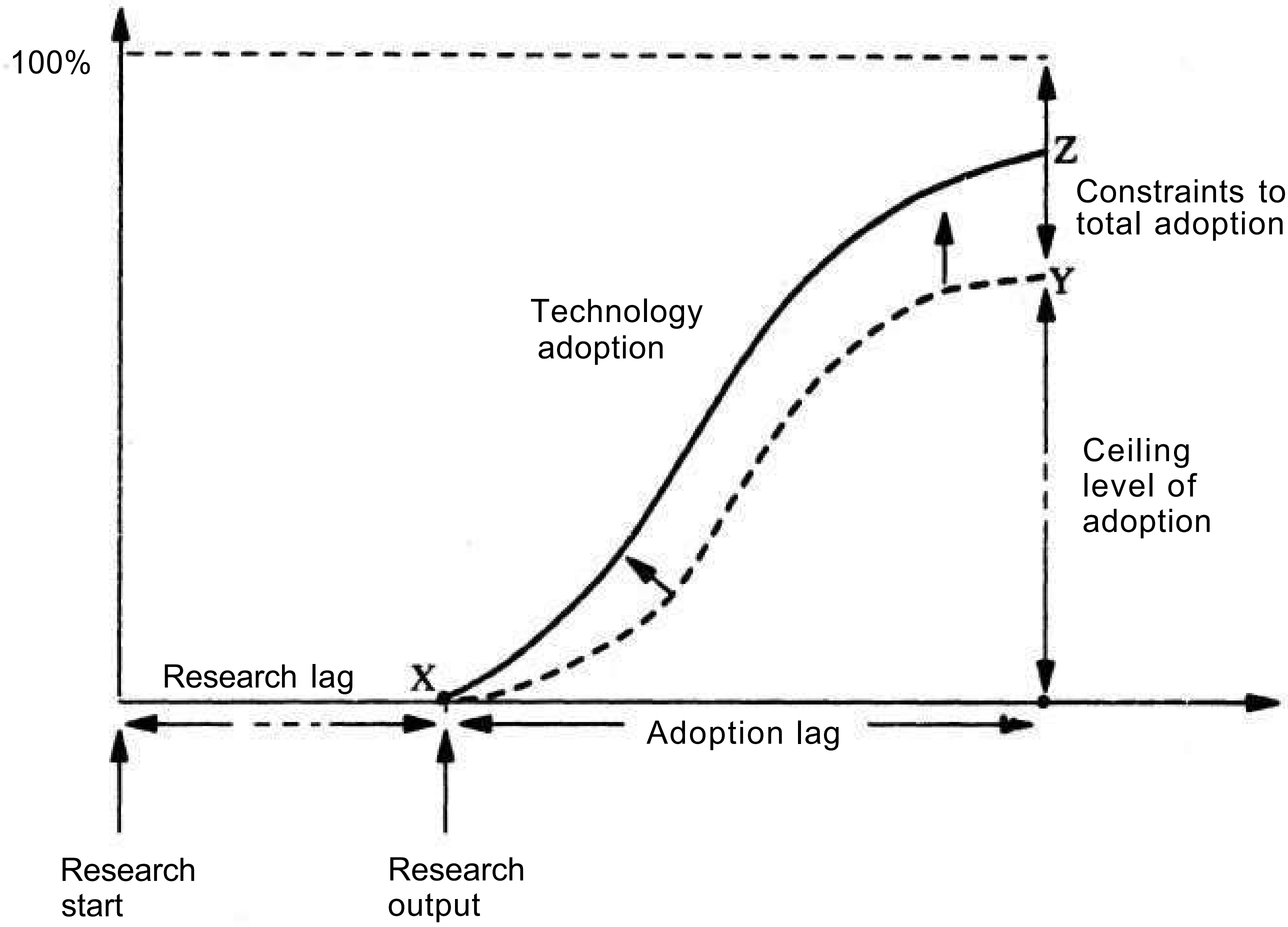

Figure 1. A typical technology adoption curve.

Conceptually, the impact of OFAR may be measured by the extent to which the adoption curve is pushed upwards (from XY to XZ, as shown in Figure 1) as information feedback through OFAR accelerates technology adoption, given the structure (extension, market, roads, etc.) of the location considered. Aside from OFAR, several factors like good extension network, processing structures, road infrastructure, and assured market enhance technology adoption. Measurements of the level and extent of technology adoption compound the contributions of all these influencing factors. Thus, analysis of technology adoption due to each factor requires subsamples involving homogeneous structural environments.

Measurement of Economic Impact of Research

Impact assessment involves three basic steps: (1) choice of evaluation framework; (2) generation of information about current and new technology; and (3) estimation of welfare gains from the use of the new technology.

The choice of an evaluation framework has been the subject of extensive enquiry. Two approaches in assessing the welfare gains from research are commonly used. The first measure, i.e. the value of the increase in output, relies on estimates of the expected change in output due to research valued at the current or expected commodity price. The second measure, more commonly referred to as welfare-theory based measure, uses the principle of economic surplus to measure the size and distributional consequences of research-induced technological change. Both approaches utilize the basic concepts of demand and supply in representing the production and consumption environment.

Substantial differences can occur between the two measures. Consideration of stability of estimates under uncertain demand and supply conditions favors the use of the second measure. Nevertheless, a good understanding of the underlying production and consumption environment is required in choosing an appropriate measure and in interpreting the estimates.

The net benefit from the research effort is computed by subtracting the actual research costs plus additional costs involved in the use of the new technology and accounting for the extent to which the technology is adopted by farmers. As the benefit due to research accrues for several years, the string of benefits is expressed in terms of its present value.

Refinements to the above simple approach have expanded the framework to incorporate spill-over effects of research across locations/commodities, multi-regional trade, and government intervention.

Measures of Profitability of Component Technologies

Complementing the methodology presented above are two useful techniques for identifying profitable component technologies: (1) use of partial budgets; and (2) marginal analysis. Partial budgets are used to identify economically viable or profitable technologies by comparing changes in costs with corresponding changes in benefits. A component technology is said to be more profitable than another when the increase in benefits due to a component technology outweighs the corresponding increase in cost.

Marginal analysis identifies the most profitable component technology as one with the highest net benefit with a marginal rate of return (MRR) greater than the minimum rate acceptable to farmers, where MRR is computed for each adjacent pair of treatments, i.e.,

MRR = change in benefit cost/change in variable cost x 100.

Data Elements for Impact Assessment Work

The basic information required to apply the Value in output change' approach are: (1) change in level of production; (2) output price; (3) research cost; and (4) adoption level.

To utilize the welfare-theory based measure, the following minimum data set is needed: (1) change in production and yield levels; (2) price and cost of production; (3)research cost; and (4) adoption level.

Information about changes in farmer's practices (e.g., crop rotation) and the resource base (e.g., soil characteristics, erosion index, water quality, and soil fertility) are complementary information that allows an evaluation of changes that may be attributable to technology adoption.

Examples of Evaluation

Example of evaluation for a component technology (marginal analysis) is given in Table 1 and for crop improvement/management package (welfare theory-based measure) is given in Table 2.

The results in Table 1 indicate that the application of basal lime is most profitable, capturing most of the net benefits at a much lower cost. Analysis of the cost structure in Table 2 shows that the variable costs per hectare are substantially lower before research as opposed to after the technology is developed and adopted. Despite this, with the very large yield increase from 7.5 to 35 t ha^{-1} it is found that the unit cost of production is reduced substantially, by approximately 50%.

Further analysis of the farmers' cost structure given in Table 2 can be made by considering some assumptions on research and adoption lags of 9 years and an adoption pattern to provide an estimate of the benefits from the research. This assumption considers that the availability of the new technology results in 3 additional years of staggered adoption so that it is likely to be 12 years before all farmers have replaced the old practice. Once all components are accounted for, including the cost of research and an 8% discount rate, the total benefit from research is estimated to have a present value of $2.9 million. The internal rate of return for this situation is approximately 20%, indicating a relatively high payoff.

Table 1. Split application of lime: marginal rate of return.

Input/output parameters	Treatment: No lime	Basal lime at 250 kg ha^{-1}	Basal lime at 250 kg . ha^{-1} and dressing lime at 250 kg ha^{-1}
Yield (kg ha^{-1})	1210	2530	2870
Gross field benefit ($) (Farm Gate price = $.30 kg')	363	759	861
Cost of lime ($)	0	7.50	15.00
Cost of labor for lime application ($)	0	1.50	2.50
Total variable cost ($)	0	9.00	17.50
Net benefit ($)	363	750	843.50
Net benefit increment	-	387	94
Variable cost increment	-	9	8.5
Marginal rate of return (%)		43	11

Table 2. Cost structure of research impact analysis for crop improvement/management research.

Output/Cost	Unit price (Rs)	Before research Quantity	Before research Cost (Rs)	After Research Quantity	After Research Cost (Rs)
Variable costs ha[1]					
Labor					
Land preparation (days)	85.58	35.0	2995.3	35.0	2995.3
Planting (days)	85.58	6.0	513.5	6.0	513.5
Weeding (days)	85.58	12.0	1027.0	24.0	2053.9
Irrigation (days)	85.58	2.0	171.2	10.0	855.8
Fertilization (days)	85.58	1.0	85.6	5.0	427.9
Spraying (days)	85.58	0.0	0.0	15.0	1283.7
Harvesting (days)	85.58	50.0	4279.0	80.0	6846.4
Hauling, grading, packaging (days)	85.58	25.0	2139.5	36.0	3080.9
Fertilizer (50 kg)	400	1.0	400.0	15.0	6000.0
Pesticide (bottle)	300	0.0	0.0	5.0	1500.0
Seeds (gm)	10	0.0	0.0	30.0	300.0
Packaging materials			200.0		7500.0
Miscellaneous (plastic bags, etc.)			0.0		5000.0
Equipment/animal labor					
Land preparation (days)	100.00	27.0	2700.0	27.0	2700.0
Hauling, weeding (days)	100.00	25.0	2500.0	25.0	2500.0
Transportation	22	2.0	44.0	5.0	110.0
Total variable costs			17055.0		43667.4
Fixed costs					
Owned land: rental value, tax	5	378.0	1890.0		1890.0
Land rent: lease rental	1	725.0	725.0		725.0
landlord share	5	289.0	1445.0		1445.0
Depreciation and interest on capital	1	399.0	399.0		399.0
Total fixed costs			4459.0		4459.0
Total costs			21514.0		48126.4
Output ha^{-1} (t)		*73*		35.0	
Change (%)				366.7	
Unit cost assessment					
Unit variable cost			2274.0		1247.6
Unit fixed cost			594.5		127.4
Unit total cost (Rs t^{-1})			2868.5		1375.0
Unit cost reduction					
Unit variable cost reduction					1026.4
Unit fixed cost reduction					467 1
Unit total cost reduction (Rs t^{-1})					1493.5
Unit cost reduction (%)					52.1

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Involvement of Farmers and Extension Workers in On-farm Adaptive Research on Food Legumes and Coarse Grains

C.E. van Santen[1]

Introduction

The experience gained during the maize production program in East Java, Indonesia, during the 1980s is relevant for similar exercises in the region, which seek to reach the same goals through farmer participation (Harrington et al. 1992). This paper briefly outlines the involvement and the link between farmers, extension workers, and agricultural researchers in their joint efforts for agricultural development.

A survey implemented 7 years after the start of the maize on-farm research program indicated that over 70% of the farmers had adopted three recommendations to improve maize yields, resulting in average yield increases from 1 to 1.5 t ha^{-1}. However, another set of three recommendations relating to fertilizer application (which potentially could increase yields by another 1 to 1.5 t ha^{-1}) with a high marginal rate of return, was only adopted by a small percentage of the farmers in the study area.

The on-farm adaptive research (OFAR) team had asked farmers and extension workers for advice and assistance throughout the program. The results of the adoption survey showed that the OFAR research team had partly succeeded in its aims. The survey results raised the following questions:

- Why did farmers adopt three of the recommendations and reject the other three?
- Should farmers and extension workers have been involved in the research decision-making process with researchers accepting farmers more as colleagues instead of advisors?
- Would farmers' involvement have resulted in a different and more efficient focus on the research objectives, in line with the farmers' needs?
- Should there have been greater involvement of the extension workers?

These questions highlight the importance of the involvement of farmers and extension workers in on-farm adaptive research.

Farmer Participation in OFAR

For a fruitful discussion of the role of farmers and extension workers in OFAR it is necessary to understand what OFAR is within the context of agricultural development. An important determinant of agricultural development is increase in farm

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income and agricultural productivity. Availability of improved technologies and an increased demand for agricultural produce are essential for achieving and sustaining increased agricultural productivity.

The specific task of OFAR is to adapt improved technologies into practical recommendations, which can be easily adopted by farmers from a specific recommendation domain.

A recommendation domain is a group of farmers with similar agroclimatic and socioeconomic circumstances, so that all group members can benefit from the recommendations.

The guiding principle of OFAR is to focus on problems and possible solutions under representative conditions, relevant for a defined group of farmers. Using the farming systems perspective, it involves farmers, extension workers, and scientists. It aims to convert near-term solutions into practical recommendations and establish a feedback mechanism between on-farm and on-station research. Near-term solutions are new technologies developed by research such as new varieties or improved pest- and disease-management practices.

The main stages in the OFAR research process are:

- Diagnosis: problem identification; conduct of informal and/or formal surveys; review of secondary data.
- Planning: selection of priorities for research; and design of on-farm experiments.
- Experimentation: experimentation in farmers' fields, formulation of improved technologies under farmers' conditions.
- Assessment: assessment by farmers; agronomic evaluation; statistical analysis; and economic analysis.
- Recommendation: formulation of recommendations; and demonstration of improved technologies to farmers.

It is obvious that OFAR can only be meaningfully implemented under the conditions of well-established cooperation between farmers, extension workers, and agricultural researchers. It is therefore useful to examine the role, position, and motivations of these three partners in agricultural development, in particular those involved in food legumes and coarse grains (FLCG) crop development.

Farmers

Food legume and coarse grain crops are grown mainly by small farmers with limited capital resources, operating in marginal areas with low potential. Many small farmers are experimenters themselves and interested in increasing their production to raise their income. However, in view of the limited risks they can take and the specific agroecological situation of their farm (soils, climate) they have to scrutinize any new technology before they can adopt it. Thus farmers often first adapt a new technology to their specific circumstances before adopting it. Farmers adopt new technologies stepwise, often by using the new technology initially only on a part of their fields.

Extension Workers

The main task of the extension workers is to disseminate and demonstrate new technologies to farmers. However, in practice, extension staff are often burdened with many other assignments. A major bottleneck is that extension and research are often organized in separate agencies, without adequate communication and interaction between them. Potentially, however, village-level extension workers assigned to rural areas have good access to farmers and can provide feedback to research.

Agricultural Researchers

Agricultural researchers, in general, place greater emphasis on basic research and academic work. On-farm adaptive research offers fewer rewards as compared with more fundamental types of research. Hence, the interest and commitment to undertake OFAR is often limited.

Partners and Problems

It is obvious that there are a number of constraints among the three potential partners in OFAR. These constraints should be addressed and resolved as the ultimate justification for agricultural research is to raise agricultural productivity.

The agroclimatic conditions on research stations are usually not representative of farm conditions, due to different soil conditions, crop management regimes, pest and disease control measures etc. The farmers of the recommendation domain concerned possess location-specific knowledge. Researchers need to obtain this information through intensive contacts with farmers and extension workers residing in rural areas.

Experimentation in farmers' fields ensures that technologies are formulated under farmers' conditions. Because of this farmer orientation, on-farm research has to identify beforehand the farmers for whom the research is intended (Byerlee and Collinson 1980).

Cooperation between Farmers and Researchers

Biggs (1989) has given a practical description of the four main types of farmer participation in OFAR.

Contract Participation

Scientists contract with farmers to provide land or services. In this approach the farmer's role is passive and participation is not an explicit objective. Multilocational testing of new varieties by plant breeders is a good example of contract participation.

Consultative Participation

Scientists consult farmers about their problems and then develop solutions. This type of participation has been compared with the doctor-patient relationship. Researchers use formal and informal surveys to diagnose priority problems, and design experiments to test various solutions or to better understand identified problems. Researchers involve farmers mostly in the diagnosis and then later in the evaluation of proposed solutions.

Collaborative Participation

Scientists and farmers collaborate as partners in the research process. This approach involves more intensive and continuous interaction. Researchers actively draw on farmer's knowledge and experimentation in seeking solutions to identified constraints.

Collegiate Participation

Scientists work to strengthen farmers' informal research and development systems in rural areas. The emphasis is on increasing the ability of farmers to carry out research on their own as well as to request information and services from the formal research system.

Cooperation between Researchers and Extension Workers

Researchers and extension workers should cooperate to:

- Identify and address specific problems;
- Test the possible solutions/options;
- Adapt technology to local conditions;
- Verify technology in the recommendation domain;
- Ensure that inputs are available;
- Provide information to farmers;
- Facilitate communication between researchers and farmers;
- Provide feedback on the basis of farmers' reactions to new technologies.

Conclusion

These notes on the involvement of farmers and extension workers in the OFAR process and their cooperation with researchers have only touched on some of the essential aspects of implementing an efficient on-farm research program. It should be stressed that proper involvement of farmers and extension workers with researchers is important in all steps of the OFAR process to develop practical recommendations which help farmers to increase productivity and raise their income through the production of FLCG crops.

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Use of Environmental Information Systems in Analyzing Crop Adaptation and Production Constraints as an Aid to On-farm Research

C. Johansen[1], S.M. Virmani[1], Tran Van Lai[2], Nguyen Hai Nam[2], and S.N.Nigam[1]

Introduction

A focused research and development program for a crop or cropping system should be based on a comprehensive analysis of the relevant database for the target region. This database should comprise production and area trends, and factors affecting production including biotic, abiotic, socioeconomic, and utilization constraints. The information should be presented as clearly as possible in order that it may be adequately interpreted by a wide range of persons, including nonspecialists. The recent development of geographical information systems (CIS) —computer-based packages which allow rapid plotting of large data sets as digitized maps — is a great help in this area. GIS packages were originally developed for land-use planning to depict mainly geographical features such as soils, water courses, administrative boundaries, vegetation pattern, etc. However, for crop research it is also necessary to plot climatic factors, incidence and extent of biotic and abiotic constraints, and socioeconomic factors. Among researchers concerned with crop adaptation and interested in exploiting GIS technology, the terminology of 'environmental information systems' (EIS) is being increasingly used, as this more comprehensively describes what is plotted.

At ICRISAT, we had earlier attempted mapping production zones and production constraints of groundnut, chickpea, and pigeonpea crops in various Asian countries but without the aid of EIS. Results of this manual cartographic exercise are presented in an ICRISAT Research Bulletin (Virmani et al. 1991), which proved to be a useful base line of knowledge available up to the end of the 1980s. But it was a laborious and time-consuming exercise.

We therefore established an EIS facility. In a collaborative exercise between the International Center for Agricultural Research in Dry Areas (ICARDA) and ICRISAT, EIS is being used to plot out the factors affecting adaptation and production of chickpea in the West Asia and North Africa (WANA) region. We are thus in the process of adapting EIS to answer questions concerning crop adaptation.

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2. Legumes Research and Development Center, National Institute of Agricultural Sciences, Hanoi, Vietnam.

The purpose of this paper is to briefly describe the use and potential of EIS in understanding crop adaptation and in research prioritization. We are beginning an EIS study of adaptation of groundnut in Vietnam, which we will draw upon to illustrate the application of EIS to crop research and development.

Description of EIS

A landscape is composed of many components: land resource base, vegetation, man-made boundaries, climatic factors, etc. The advent of computers with large memories has allowed digitization of such data sets in the form of individual map layers by using EIS technology. Existing maps can be directly digitized on digitization boards, whereby boundaries are reproduced on the computer screen on the basis of grid points. Different map layers can be instantaneously superimposed so as to help in understanding better the relationships between them. This procedure can also be done by standard cartographic means but slowly, laboriously, and with a high probability of transcription errors.

The scale of the landscape may vary from global to farm size. For example, at ICRISAT we have been using global plots of crop distribution in relation to various factors to set research priorities for our mandate crops on a global basis. At the other extreme, we use an EIS system for database management of the ICRISAT research farm. But mostly we work at the level of a country, or a region within a country, to understand crop adaptation.

Use of EIS for Groundnut in Vietnam: a Case Study

Since 1976, the area, production, and yields of groundnut in Vietnam have shown an increasing trend (Fig. 1). To establish the primary production zones of the crop, we plotted the area distribution on a provincial basis (Fig. 2). In Vietnam, the number of provinces is sufficiently large so as to adequately delineate country-wide distribution of the crop. Greater precision can be achieved by plotting out district data' (e.g. for a portion of the country), but we first attempted a countrywide overview. There have been some changes in provincial boundaries in recent years and this complicates display of the time trends. Where changes have occurred, district-level data are required to accurately represent production changes over time. Figure 2 indicates where the increases in area have occurred between 1976 and 1990, mainly uniformly across the country. In 1976, groundnut yields were highest in some southern provinces. In 1990, yields generally increased in southern provinces and in the Red River Delta area in northern Vietnam (Fig. 3).

We are examining these production data in relation to various environmental factors (data are being assembled and digitized). For the information on soil, we will use the FAO-UNESCO soil map of the world. The major climatic factors to consider are soil-water status and temperature. For groundnut grown in seasons other than the

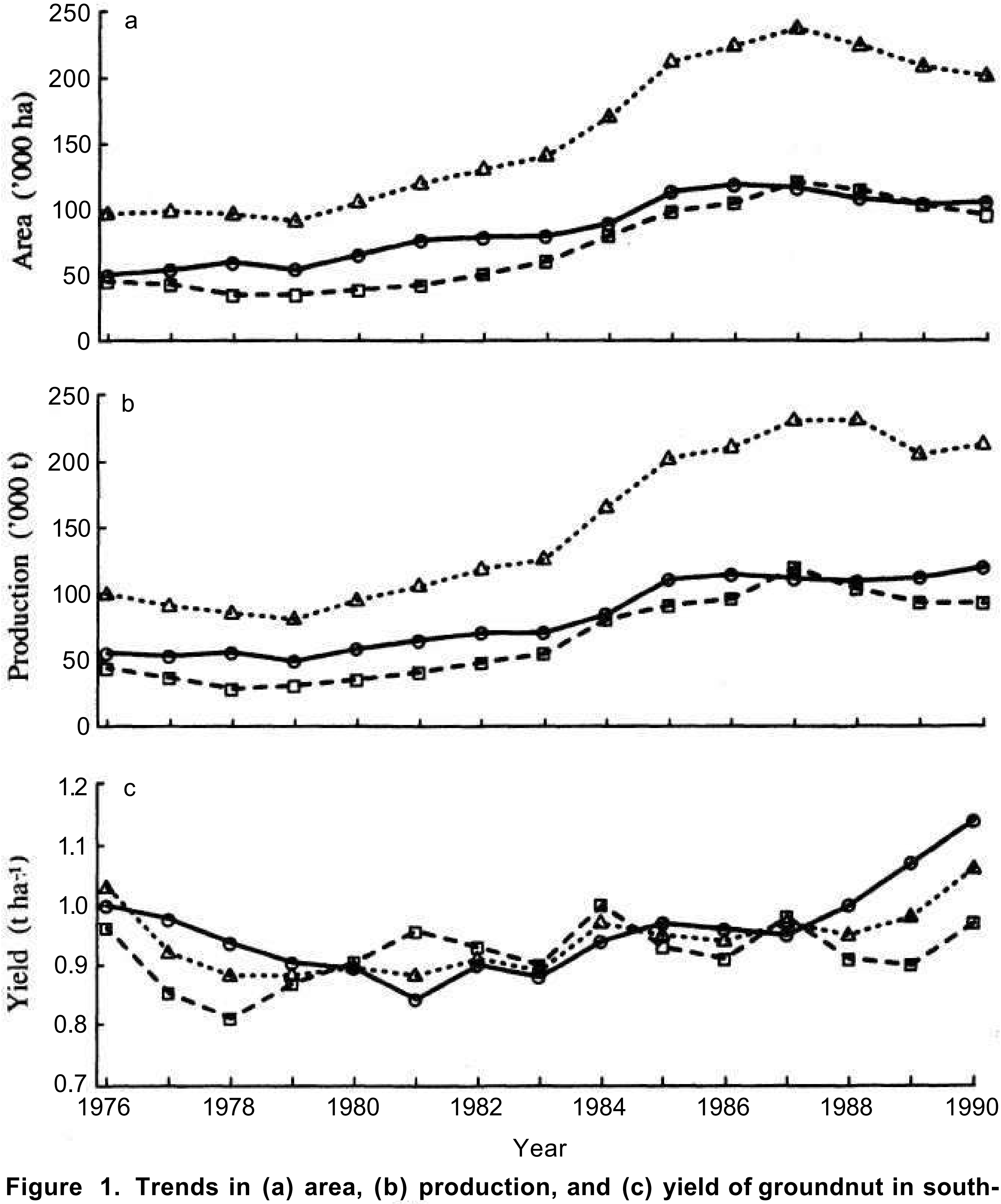

Figure 1. Trends in (a) area, (b) production, and (c) yield of groundnut in southern (o), northern (□), and total (Δ) Vietnam from 1976 to 1990.

rainy season, as is normally the situation in Vietnam, isohyets for total rainfall may not be of value in interpreting groundnut adaptation. It is thus necessary to establish and map the mean soil-water balance during the cropping season, based on rainfall, evapotranspiration, and soil-water holding capacity. Simple soil-water balance models are available for doing such an analysis. However, due to the variability in rainfall

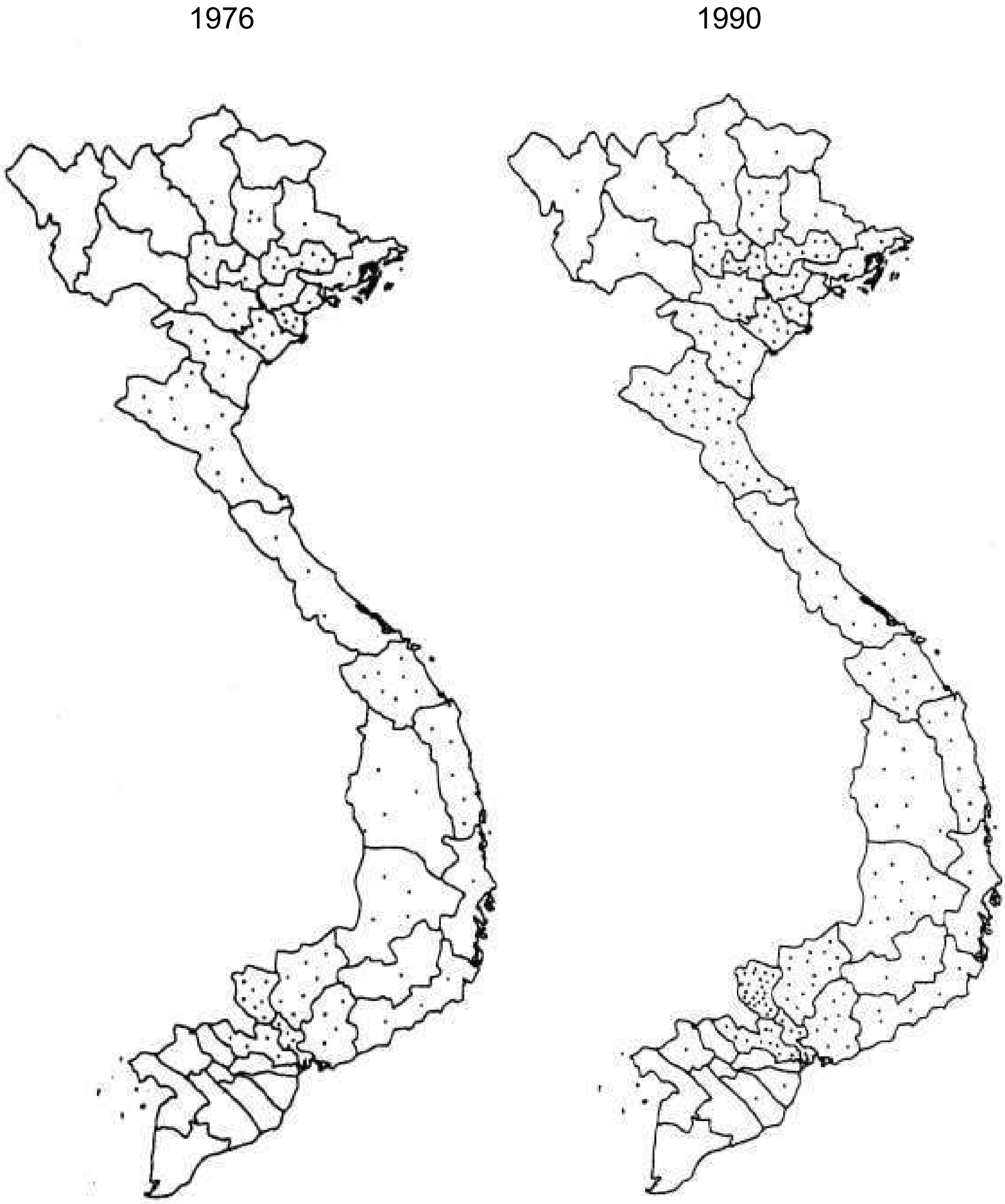

Figure 2. Area sown to groundnut in each province of Vietnam in 1976 and 1990. (Each dot represents 1000 ha.)

distribution between years, it would also be necessary to factor in probability values for available soil water at any particular time during the growing season. Probability analyses of the type used for rainfall data (Virmani et al. 1982) could be adapted to apply for available soil water. The challenge before, us is to incorporate such probability information into EIS plots. These types of analyses will help us to establish possible drought limitations and to identify genotypes and crop management practices that will alleviate the problem.

As waterlogging is at least as important a constraint as drought towards the end of the growing season in northern Vietnam and during the rainy season in southern Vietnam, it is also desirable to delineate probable incidence and extent of water-

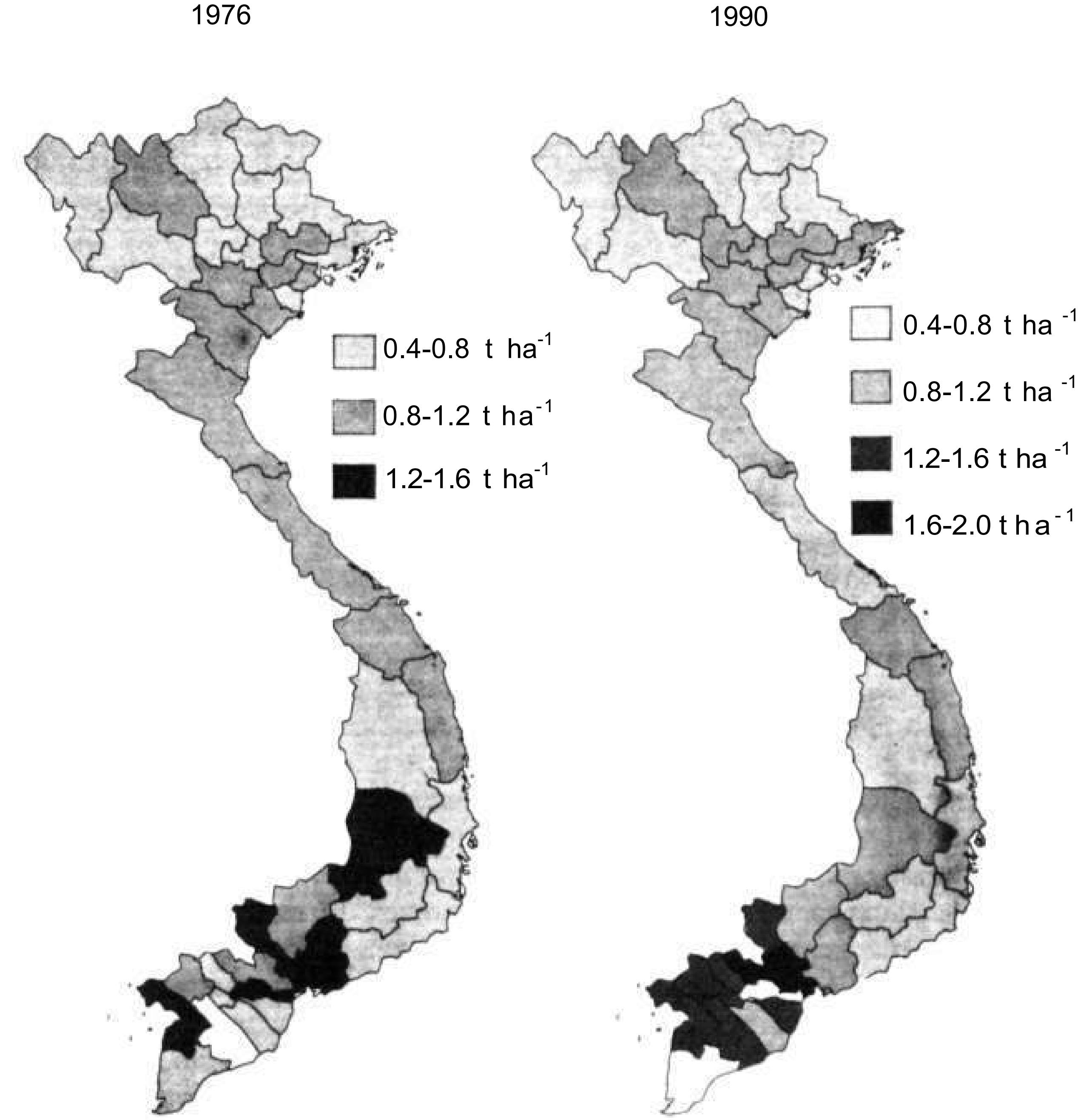

Figure 3. Groundnut yields in each province of Vietnam in 1976 and 1990.

logging damage. This may be done by calculating probability of incidence of rainfall on a fully charged soil profile.

We will also plot critical temperature isotherms that limit growth and yield of groundnut. Probability considerations will also apply to critical temperature plots, as discussed for available soil water. This information will guide us in genetic improvement of high or low temperature tolerance. There are also management options to overcome adverse temperature effects. For example, for low temperature stress at the establishment of the winter-spring crop in northern Vietnam, sowing of sprouted seed or use of polythene mulches covering the seed bed are available options.

We are also gathering information on pest and disease constraints to groundnut in Vietnam, which will be integrated into the EIS. We will examine how biotic constraints relate to various soil and climatic factors, by overlaying such databases, so as to gain insight into possible causal factors and control options. However, survey data for biotic stresses are generally incomplete, for any crop in any country. This is further complicated by seasonal changes in the pattern of pest and disease incidence. While we do not expect to be able to plot out biotic stresses in a comprehensive manner, we would recommend a more systematic method to record biotic stress data in a format compatible with EIS. This would require a uniform rating system to estimate the damage intensity or, preferably, extent of yield loss due to a particular biotic constraint.

Prospects for EIS in the Research and Development Process

EIS is proving to be a valuable tool in the research prioritization process, which is an improvement on the usual empirical way of deciding research priorities. Using EIS format to present research proposals for administrative/donor support is also seen as an advantage. EIS can be used to identify areas with potential for increased production of a crop, either by increases in yield or area under cultivation. It would thus guide us to site on-farm research trials for adapting improved technology.

EIS not only effectively displays current knowledge on crop constraints but also highlights gaps in that knowledge. It indicates where to direct surveys to obtain missing information. EIS provides both an incentive and a means (e.g., through standardized data entry format) for more comprehensive and regular surveys. This is a particularly important consideration for identifying and rating biotic constraints, about which there is usually limited information, especially regarding the distribution and fluctuation in incidence and severity over time.

EIS helps in better documentation, and attractive display of impact of research and development efforts. It can also display scenarios based on 'what if questions. It facilitates integration of the continuum: basic/applied/adaptive research—extension—adoption—impact. It thus allows on-farm research to be placed in perspective and provides a feedback mechanism among components of the continuum.

EIS technology should be adopted as soon as possible by national agricultural research systems (NARS) for their use as a planning tool for crop and agricultural systems improvement on a national scale. International agricultural research centers (IARC) have a role to play in facilitating adoption of EIS by NARS, by helping to identify financial support to establish EIS and by providing training in the technology. IARCs can also assist by ensuring linkage to existing digitized databases, to help design standardized database assembly systems, and to promote compatibility of databases. The involvement of NARS is basic for obtaining the necessary data for EIS, and NARS should take maximum advantage of using the resultant databases.

In summary, EIS should facilitate future:

- research efficiency,
- development of research domains, and
- development of application domains (where best to apply established technologies).

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Case Studies in On-farm Research

Indonesia

N. Saleh[1], T. Adisarwanto[1], D.M. Arsyad[2], and Sumarno[1]

Introduction

Groundnut is an important source of protein in the Indonesian diet. Most groundnut is consumed after roasting or boiling, or in the form of chips, cookies, cakes, and snacks. Only a small portion of groundnut production is used for oil extraction. Groundnut production has gradually increased over the previous decade, due mainly to increases in harvested area (Table 1). Over 60% of the country's groundnut production is in Java. Groundnut production has not met national demand, as around 50 000 t of pods are imported annually.

Most groundnut production (66%) is under rainfed conditions with the remainder on irrigated wetland. The cropping system varies among locations and sowing seasons. In rainfed drylands, groundnut is usually sown at the beginning of the rainy season or in the late rainy season following the harvest of upland rice. The crop is generally grown in monoculture, but is sometimes intercropped with maize or cassava.

Using improved technology in researcher-controlled plots 2.0-2.5 t dry pods ha^{-1} could be obtained. However, at the farmers' level, average yields still remain low, at approximately 0.7-1.5 t ha^{-1}. Some reasons for this groundnut yield gap are:

- The present package of technologies for groundnut production is still too general. Large environmental variation requires specific technologies updated for each agroecosystem.
- Farmers cannot fully adopt the recommended technology due to resource limitations or because the technology remains too complicated.

On-farm research conducted jointly by researchers, agricultural extension personnel, and farmers is aimed at solving these problems. This paper summarizes the results obtained so far in the AGLOR groundnut project in Indonesia.

Study Area

The study areas for groundnut on-farm research were selected to represent the major groundnut production systems in Indonesia. Subang district, West Java was chosen to

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2. Bogor Research Institute for Food Crops, Bogor, Indonesia.

Table 1. Harvested area, production, and yield of groundnut in Indonesia (1980-1990).

Year	Area harvested ('000 ha)	Production ('000 t)	Yield (t ha^{-1})
1980	501	467	0.93
1981	508	475	0.93
1982	469	443	0.95
1983	478	457	0.96
1984	530	524	0.99
1985	497	499	1.00
1986	456	564	0.99
1987	551	533	0.97
1988	607	587	0.97
1989	620	619	0.99
1990	635	652	1.03

represent irrigated cropping; and Tuban district, East Java, to represent rainfed cropping systems. The study area in Subang district included Jabong and Cisaga villages in Subang sub-district and Dawuan and Menyeti villages in Kalijati sub-district, mostly having red latosol soils. Groundnut is usually grown from Jul to Sep/Oct as a third crop following two crops of rice.

Tuban district in East Java represents a rainfed dryland farming area for groundnut. Annual rainfall is 1500-1900 mm and the rainy season normally starts in Nov, reaches a peak in Dec/Jan and ends in Apr. Maize/cassava intercrops are sown in Nov, with groundnut sown between cassava rows after harvest of maize in Feb/Mar. In Tuban district, the dominant soil type is Mediteran (calcareous, red sandy loam). The study areas included Semanding and Tunah villages in Semanding sub-district and Padasan and Karanglo villages in Kerek sub-district.

Diagnostic Survey Results

A diagnostic survey in selected villages of the study area was conducted in Dec 1990 to identify constraints and establish on-farm research priorities.

In Subang district farmers apply little or no fertilizer or chemical spray to groundnut. The major costly inputs for groundnut production are seed and labor. But in practice farmers do not incur the cost of harvesting, because they sell the crop to contract buyers while it is in the field. Groundnut is more profitable than soybean. Marketing of groundnut was not considered to be a problem. Although prices fluctuate depending on the total area harvested, the variation was not high enough to cause concern. Forty-three percent farmers in the survey villages owned less than 0.5 ha of land and only a few had 1-2 ha.

In Tuban district, groundnut is a dominant crop and is considered more profitable than maize. Most farmers do not allocate optimum inputs due to their limited resources. Only a few farmers with adequate resources apply urea (50-75 kg ha^{-1}) and use pesticides for groundnut. Most farmers in survey villages owned less than 0.5 ha land, with only a few having more than 1 ha.

Constraint Prioritization

Constraints for groundnut production were prioritized based on the information and data obtained during the survey. In Subang district, the first priority was assigned to poor seed quality and low plant population, followed by rat damage and poor drainage. Insect pests (white grub and leaf feeders) and diseases (wilt, leaf curl, and yellow leaf/chlorosis) were third in priority (Table 2). In Tuban district, pest problems and nutrient deficiency were considered as first priority (Table 2). Leaf spot, rust diseases, and drought were of second priority.

However, not all of the prioritized constraints could be considered as viable topics to be studied in on-farm research. For example, the rat problem in Subang district, was not an area that could be adequately addressed by on-farm researchers. Further, since the survey was conducted only at one time, additional observations would be needed to confirm the data obtained on this survey.

Table 2. Prioritization of constraints to groundnut production in Subang and Tuban districts, Java, Indonesia, 1991.

Subang district		Tuban district	
Constraint	Priority[1]	Constraint	Priority
Insect pests		Insect pests	
White grubs	3	Worms	1
Aphid/Thrips	2	Leaf feeders	1
Leaf feeders	3	White grub	3
		Aphids	3
Diseases		Diseases	
Wilt	3	Sclerotium root rot	2
Leaf curl	3		
Leaf chlorosis/yellowing	3		
Rat damage	2	Drought	2
Drainage	2	Nutrient deficiency	1
Plant stand	1	Water logging	3
Seed quality	1		
Excess vegetative growth	3		

1.1 = high priority; 2 = medium priority; 3 = low priority.

The following topics were selected for on-farm research activities in each target area, in addition to testing of improved package of technology.

Subang District

- Seed treatment, proper sowing methods, spacing, and good quality seed of varieties to address the problem of poor seed quality and low plant population.
- Broad beds and furrows, or drainage channel every 2-3 m, to address the problem of poor drainage.
- Pest/disease survey and control (with chemical sprays), to address the problem of pests and diseases.
- P and K fertilizers, Ca/Mg application (after soil analysis) for better fertilizer management.

Tuban District

- Pest/disease survey and control (with chemical sprays), to address the problems of pests and diseases.
- Soil and plant tissue analysis, fertilizer treatment, to address the problem of nutrient deficiencies.
- Rainfall distribution analysis, sowing date adjustment, drought-resistant genotypes, broad beds (drainage channels), to address the problems of drought and waterlogging.

Results

Packages of technology based on previous research were proposed for testing in farmers' fields. Additional research on components of the package was also done to refine the package. Results of research conducted in Subang and Tuban districts are summarized below:

Tuban District

1991 Results

Technology package testing. In dry season I (Mar-Jul 1991), three packages of improved technology (Table 3), were compared with farmers' practice, in Semanding and Padasan villages, using 250 m^2 plots for each package of technology. Groundnut yield increased with increasing input levels (Table 3).

In dry season II (Jul-Oct 1991), only low and high input packages of technology (modified from the first trials in dry season I) were tested in irrigated lowland at Semanding and Palang. Due to the high incidence of pests and diseases, especially thrips, aphids, and peanut stripe virus (PStV), the increased levels of input did not

Table 3. Package of technology alternatives[1] tested on farmers' fields and mean dry pod yields in the 1991 dry season I (Mar-Jul) and II (Jul-Oct), Tuban, Indonesia.

Technology component and yield	Dry season I				Dry season II		
	Farmers' practice	Package with inputs			Farmers' practice	Package with inputs	
		Low	Medium	High		Low	High
Technology component							
Tillage	+	+	+	+	+	+	+
Seed beds (2 m)	-	-	+	+	-	+	+
Planting method							
Irregular spacing	+	-	-	-	+	-	
40 x 10 cm spacing	-	+	+	+	-	+	+
Fertilizer[2]							
Urea (kg ha^{-1})	25	50	50	50	-	25	50
TSP (kg ha^{-1})	-	50	100	150	-	25	75
KCl (kg ha^{-1})	-	50	50	100	-	25	50
FYM (t ha^{-1})	-	-	5	5	-		2
Micronutrients	-	-	-	+	-		+
Weeding (no.)	1	1	2	2	1	2	2
Pest control (no. of sprays)	-	-	2	2	-	1	2
Disease control (no. of sprays)	-	1	2	2	-	1	2
Variety							
Local	+	-	-	-	+	+	+
Kelinci	-	+	+	+	+	+	+
Plant population (plant m^{-2})	27.5	25.0	25.0	25.0	25.0	25.0	25.0
Seed treatment[3]	-	-	+	+	-	+	+
Yield (t ha^{-1})[4]	1.44	1.61	1.82	2.16[5]	1.24	1.50	1.48

1. + = with; - = without.
2. TSP = triple superphosphate, KCl = potassium chloride (= muriate of potash), FYM = farmyard manure.
3. Captan in dry season I and Furadan® 3G in dry season II.
4. Mean yield for 6 farmers' fields in dry season I and 7 farmers' fields in dry season II.
5. Significantly (*P* <0.05) higher yield than obtained by farmers' practice.

significantly improve pod yield compared with that obtained with the farmers' practice (Table 3).

Varietal adaptation. Three improved groundnut varieties (Pelanduk, Macan, and Banteng) were tested in the dry season of 1991. Under irrigation at Semanding, Pelanduk yielded (2.20 t ha^{-1}) better than Macan (1.54 t ha^{-1}) or Banteng (1.60 t ha^{-1}) but differences were not significant. Yields without irrigation at Kerek were 1.83 for Pelanduk, 1.38 for Macan, and 1.62 t ha^{-1} for Banteng. Although Pelanduk gives a better yield, its seed coat is red and it is thus not accepted by Tuban farmers, who prefer white seeds. The Banteng variety was therefore suggested as an alternative variety for upland cultivation in Tuban district.

Pest and disease survey. Pest and disease assessment surveys were conducted in May and Nov 1991, covering the main groundnut-growing areas of Tuban district. Pest and diseases incidence was much higher in Nov than in May. However, in both cropping seasons early and late leaf spots, and rust are considered the most important diseases on groundnut in Tuban district.

1992 Results

Technology package testing. Two sets of improved packages of technology (Table 4), were compared with farmers' practice at Padasan, Karanglo, and Tunah villages. Dry pod yields increased significantly with each increase in level of input (Table 4). Variability in pod yield between locations (villages) is attributed to the variability in soil fertility and cropping system (most farmers at Padasan and Karanglo planted groundnut in intercrops with cassava). The components in the low and high input packages which contributed most to increased yields were considered to be the use of broad beds and plant protection.

Table 4. Evaluation of alternative packages[1] of technology in farmers' fields, 1992 dry season, Tuban, Indonesia.

Technology component and yield	Farmers' practice	Low input	High input
Technology component			
Soil tillage	+	+	+
Seed beds (2-3 m)	-	+	+
Planting method			
Irregular spacing	+	-	-
40 x 10 cm spacing	-	+	+
Fertilizers[2]			
Urea (kg ha^{-1})	-	25	50
TSP(kg ha^{-1})	-	25	75
KCl (kg ha^{-1})	-	25	50
FYM(t ha^{-1})	-	-	2
Micronutrients	-	-	+
Weeding (no.)	2	2	2
Plant protection	-	1	2
Variety	Local	Local	Local
Seed treatment[3]	-	+	+
Plant population (plants m^{-2})	27.5	25.0	25.0
Pod yield (t ha^{-1})[4]			
Padasan village	0.86a	1.21b	1.69c
Karanglo village	0.92a	1.10b	1.44c
Tunah village	1.34a	1.65b	2.03c

1. + = with; - = without.
2. TSP = triple superphosphate, KCl = potassium chloride (= muriate of potash), FYM = farmyard manure.
3. Furadan® 3G.
4. Mean of 6 replications at Padasan, 11 at Karanglo, and 13 at Tunah. Treatment values within a village not followed by the same letter are significantly different at P <0.05, according to Duncan's Multiple Range Test.

Leaf diseases control. An experiment on control of rust and leaf spot diseases was conducted in the dry season 1992, comparing three treatments tested on six farmers' fields as replications. Plot sizes ranged from 900 to 1600 m^2. The results showed that two sprays of Topsin M® (0.5 kg ha^{-1}) at 7 and 9 weeks after sowing reduced disease intensity and increased groundnut yield by 27% over unsprayed treatment (Table 5).

Table 5. Effect of fungicide treatment on incidence of leaf spot and rust diseases, and on dry pod yield and its components, dry season 1992, Tuban, Indonesia.

Disease incidence and yield	Treatment[1]		
	Unsprayed	Topsin® 7 WAS	Topsin® 7 and 9 WAS
Leaf spot incidence (%)			
8 WAS	17.5a[2]	14.8ab	13.5b
10 WAS	32.2a	23.8ab	16.8b
12 WAS	44.1a	37.9b	25.1c
Rust incidence (%)			
8 WAS	33.7a	29.0a	31.3a
10 WAS	39.6a	33.4a	31.8a
12 WAS	57.2a	47.1b	39.3a
Dry pod yield (t ha^{-1})	1.3a	1.4a	1.7b
Seed mass (g 100 $seeds)^{-1}$	38a	38a	41b
Mature pods $plant^{-1}$	8a	10b	11b

1. Sprays of Topsin M® (0.5 kg ha^{-1}) at 7 or 7 and 9 weeks after sowing (WAS).
2. Values not followed by the same letter are significantly different at $P < 0.05$ according to Duncan's Multiple Range Test.

Leaf chlorosis. The effect of various mineral nutrient combinations, including N, P, K, Zn, Fe, and farmyard manure to control leaf chlorosis were studied in Tuban district. There were 16 treatments, including a control, replicated four times. The Kelinci variety was sown in 4 x 5 m^2 plots. Unfortunately, chlorosis symptoms were not severe during the growing season, and the occurrence was not homogeneous among blocks. Treatments had no significant effect on pod yield.

Tolerance to leaf chlorosis was evaluated in 120 groundnut genotypes grown in two sets of experiments (with and without potassium fertilizer) arranged in randomized block design with three replications. Yellowish symptoms occurred equally in plots with and without potassium chloride (KC1) fertilizer, with plants showing highest incidence of yellowing during the pod formation stage. However, incidence of yellowing at any stage did not clearly correlate with pod yields.

Drought resistance. Two sets of experiments (with and without irrigation) were conducted to evaluate 120 groundnut genotypes for tolerance to drought at the Muneng Experimental Farm during the late dry season of 1992. The results showed that nine genotypes, namely LM/ICGV 87165-88-B-16, ICSV 1697, G/C/LG-88-B-48, no.7529, G/C/LM-88-B-1, Lo-3/20,16, ICGV 86635, Lo-2-6, and 1CGV 86977, were relatively resistant to drought on the basis of pod yield per plot.

Subang District

1991 Results

Technology package testing. Two improved packages of technologies (Table 6) were compared with farmers' practice in Dawuan and Jabong villages in the dry season 1991. Net plot size was 500 m^2 for each package. In Dawuan, low and high

Table 6. Package of technology alternatives[1] tested for groundnut on-farm trials and mean pod yields, late dry seasons 1991 and 1992, Subang, Indonesia.

Technology component and yield	Farmers' practice (A)	Package with	
		Low input (B)	High input (C)
Technology component			
Soil tillage	+	+	+
Seed bed width	Flat	2 m	2 m
Plant spacing	Irregular	40 x 10 cm	40 x 10 cm
Sowing method	Dibbling	Dibbling	Dibbling
Seed dressing[2]	-	+	+
Fertilizers[3]			
Urea (kg ha^{-1})	-	25	50
TSP(kg ha^{-1})	-	50	100
KCl (kg ha^{-1})	-	50	100
Micronutrients	-	-	+
Insecticide[4]	-	-	+
Fungicide[5]	-	+	+
Weeding[6]	+	+	+
Irrigation[7]	+	+	+
Pod yield (t ha^{-1})			
1991			
Dawuan (n=4)	1.49	1.828	1.928
Jabong (n=3)	1.01	1.33	1.48
1992			
Dawuan (n=14)	1.55	1.87[8]	1.91[8]
Jabong (n=10)	0.85	1.208	1.15

1. + = with; - = without.
2. Benlate® at 5 (1991) or 2 (1992) g seed kg'.
3. Fertilizers applied at sowing. TSP = triple superphosphate, KCl = potassium chloride. Micronutrient application as Decamon®. lime at 500 kg ha^{-1} was also applied in package C in 1992 only.
4. In 1991 four sprays of Azodrin®/Dursban® at 1-2 weeks interval at Jabong but no sprays at Dawuan. In 1992, insecticide only applied to package C as needed.
5. In 1991 Delsene® or Dithane® at 2 g L^{-1} at 40, 50, and 60 days after sowing (DAS), 2 sprays at Dawuan (50,60 DAS) and 3 sprays at Jabong (40,50, and 60 DAS). In 1992, fungicide at 40, 50, 60 and 70 DAS only in package C.
6. Twice by hand weeding at 3 and 6 weeks after sowing (WAS).
7. Irrigation at 10-14 days interval in 1991 and 7-10 days interval in 1992.
8. Significantly (P<0.05) higher than package A.

input technology packages yielded 22% and 29% over the farmers' practice, while in Jabong the increases were 41% for low input and 57% for high input technology packages (Table 6). Yield at Jabong was lower than at Dawuan due mainly to root rot infection.

Varietal adaptation. Four varieties (Kelinci, Badak, Tapir, and local) were tested in 100 m^2 plots. In each village, two farmers' fields were used as replications. Kelinci gave the highest pod yields at both Dawuan and Jabong although yields at Jabong were much lower than at Dawuan.

1992 Results

Technology package testing. Two improved packages of technology were compared with farmers' practice at Jabong and Dawuan villages in the late dry season 1992. In Dawuan, low input technologies increased average pod yield by 21% and high input by 23%, over the farmers' practice. In Jabong, the increases were 41% for low input and 34% for high input technologies (Table 6).

Rhizobium ***inoculation and nitrogen fertilizer.*** An experiment was conducted in the late dry season of 1992 at Dawuan Kidul, Dawuan Kaler, and Jabong villages. However, at no location could *Rhizobium* inoculation (using Legin® or Rhizogen®) or nitrogen fertilizer (50 or 100 kg urea ha^{-1}) significantly increase pod yield.

Effect of liming. An experiment was conducted in the late dry season of 1992 with three treatments (lime at 0, 500, 250 basal + 250 at flowering kg ha^{-1}), at Dawuan Kidul, Dawuan Kaler, and Cibeunying villages. There was no significant effect of lime treatment on pod yield or other agronomic characters.

Control of seedling disease. An experiment was conducted in the late dry season of 1992 with four treatments: clean cultivation (stubble removal) on flat bed, clean cultivation on 2 m-wide raised bed, clean cultivation on raised bed with 2 g Benlate® kg^{-1} seed, and farmers' practice. Three trials, all located in Jabong village, showed that there was no significant effect of treatment on yield or other agronomic characters.

Future Plans

In 1993, the improved technology package (Table 7) evolved from the previous years' activities will be tested in larger areas (approximately 30-50 ha) as development research. In these studies, socioeconomic and other factors affecting transfer of technology and technology adoption by farmers will also be evaluated.

Table 7. improved package of technology for groundnut production in Subang, West Java, and Tuban, East Java, Indonesia.

Subang	Tuban
Soil tillage	Soil tillage
2 m raised bed	2-3 m raised bed
Gajah, Kelinci variety	Local variety
Good seed quality	Good seed quality
Seed treatment	Seed treatment
Regular spacing	Regular spacing
(40 x 10 cm, 1 plant per hill)	(40x10 cm, 1 plant per hill)
25 kg urea + 50 kg TSP[1] +	50 kg urea + 75 kg TSP +
50 kg KCl ha^{-1}	50 kg KCl ha^{-1}
Weeding at 3 and 5 WAS[2]	Weeding at 3 and 6 WAS
Irrigation *(4-6* times)	Fungicide; twice
Crop protection as needed	Insecticide; as needed

1. Triple superphosphate.
2. Weeks after sowing.

The project has so far facilitated better interaction and linkages between farmers, field extension agencies, agricultural services, and researchers in identifying problems and selecting viable solutions. During the project, site seminars and field days were conducted in Tuban and Subang districts, involving all of these groups. Regular review and planning meetings among NARS researchers and ICRISAT scientists have been held annually.

Nepal (Chickpea and Pigeonpea)

C.R. Yadav and L.N. Prasad[1]

Introduction

A large number of summer and winter grain legumes are grown in different parts of Nepal. Collectively, grain legumes occupy about 8% of the total cultivated area in the country. They rank fourth in total area (0.27 million ha) and production (0.16 million t) after rice, maize, and wheat. Winter legumes share 77% of the area and 79% of the production of grain legumes in Nepal.

Among winter legumes, chickpea is the third most important crop after lentil and lathyrus and accounts for about 11% of the total legumes area and production. Pigeonpea, sown in the rainy season, ranks fifth in terms of area and fourth in production (NGLRP 1991). The area, production and productivity of these two crops from 1983/84 to 1989/90 are given in Table 1.

The consumption of grain legumes is low in Nepal (about 9 kg per capita per annum as against the FAO recommendation of 36 kg per capita per annum). There is an urgent need to increase the production of Legumes to narrow this gap.

Table 1. Area, production, and productivity of chickpea and pigeonpea in Nepal from 1983/84 to 1989/90.

	Area (ha)		Production (t)		Productivity (kg ha^{-1})	
Year	Chickpea	Pigeonpea	Chickpea	Pigeonpea	Chickpea	Pigeonpea
1983/84	34 300	12 700	13 100	4 800	280	380
1984/85	25 890	14 260	116 000	10 500	610	730
1985/86	29 400	16 050	18 100	12 170	619	750
1986/87	31 100	17 470	21 100	13 350	679	750
1987/88	29 600	18 460	15 600	9 190	527	498
1988/89	28 800	17 920	17 100	12 260	593	684
1989/90	28 190	18 800	16 620	13 200	590	705

Source: DFAMS (Department of Food, Agriculture, and Marketing Services), Nepal.

Target Areas

The major chickpea and pigeonpea growing areas in Nepal include Banke and Bardia districts in the western region,. Kapilvastu in the mid-western region, and Sarlahi

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district in the central region of the country. All four districts are in the *Terai* region of Nepal. The *Terai* comprises of flat and lowland ranging in elevation from 60 to 150 m above sea level. The climate in the *Terai* is dry to humid subtropical, with distinct wet and dry seasons. The monsoon season is from Jun to Sep. The Oct to May period is usually dry, although there is some rain during the winter and spring seasons. Generally rainfall is higher in the eastern areas than the west. The soils of *Terai* are mostly alluvial sediments, comprising sandy loams to clay loams. The soils are moderately acid to neutral.

Diagnostic Survey

Diagnostic surveys were carried out in the four districts during 10-15 Jun 1991, to identify constraints to production and to plan experiments to overcome these problems.

In the upland of the target areas the major cropping system was maize (sole or intercrop with groundnut and/or pigeonpea) in the rainy season followed by chickpea, *toria (Brassica compestris* var. *toria)* or fallow in the winter season. Upland paddy and finger millet mixed with pigeonpea was also reported. In the lowland, rice was the predominant crop in the rainy season followed by legumes or *toria* in the winter season.

For chickpea, the main constraints are pod borers, plant mortality, lack of improved varieties, flower and pod drop, weeds, and drought stress at sowing.

For pigeonpea, the important constraints are pests (pod borer and pod fly), diseases (sterility mosaic and wilt), plant mortality, low temperature affecting flower drop and pod set, and lack of improved varieties.

On-farm and Backup Research

Based on the information provided by the farmers, and the technology available with the scientists, the survey team proposed a set of simple diagnostic experiments to address the identified constraints. During 1991/92 the following on-farm research and backup research experiments were conducted:

Chickpea

On-farm Trials

- Evaluation of improved and high-yielding varieties;
- Evaluation of wilt-resistant varieties;
- Weed control; and
- Sowing methods.

Backup Research

- Pod borer control by pesticide sprays;
- Causes of flower dropping; and
- Irrigation response.

Pigeonpea

On-farm Trials

- Pod borer and pod fly control;
- Evaluation of sterility mosaic resistant varieties; and
- Stem canker control.

Backup Research

- Termite control;
- Weed control; and
- Sowing method and spacing.

The on-farm trials on pigeonpea were sown in Jun/Jul 1991, and the chickpea trials in Oct/Nov 1991. Each treatment was applied to plots of 0.1 ha replicated at least 4 times in each district, with individual farmers as replications. Observations on plant stand, mortality due to wilt and root rots, weed population, pod borer damage, and seed yield were recorded in different trials. The on-farm trials were regularly monitored by the national program scientists, especially at the time of scheduled operations such as sowing, weeding, spraying, and harvesting.

Results

The results obtained from on-farm trials are summarized below:

Chickpea

Plant stand and growth were good to excellent in most trials. The trial on pod borer control consisted of two treatments; chemical control (spray of Thiodan® at flowering and Decis® at early pod filling stage) and no control (unsprayed plots). The chemical control gave an overall yield advantage of 16% (Table 2). Yields of up to 2.8 t ha^{-1} were recorded in some plots.

Three improved varieties (Dhanush in Sarlahi, Sita and Kalika in Banke and Bardia districts) were compared with local varieties for yield. The improved variety produced higher yield than the local variety at all 14 locations across districts and gave an overall yield advantage of 50% (Table 3). Similar results were obtained in another trial comparing high-yielding and wilt-resistant varieties with local varieties. Two wilt-resistant varieties (Kalika in Sarlahi, Kalika and Kosheli in Banke and Bardia districts) were used in this trial. Since the incidence of wilt was negligible in most trials it became an additional comparison of high-yielding varieties with local ones.

Table 2. Effect of chemical control on *Helicoverpa* pod borer damage and yield of chickpea in on-farm trials in Nepal, 1991/92.

District/ Location	Plant stand 10 m^{-2}		Pod borer damage (%)		Yield (t ha^{-1})		Increase in yield over unsprayed plots (%}
	Sprayed	Un-sprayed	Sprayed	Un-sprayed	Sprayed	Un-sprayed	
Banke(4)[1]	149	156	1.4	7.2	1.77	1.56	12.9
Bardia (5)	123	115	5.2	17.1	2.00	1.60	25.5
Sarlahi (5)	76	56	1.2	4.3	1.60	1.45	10.8
Mean	113	106	2.7	9.7	1.79	1.53	16.3

1. Figures *in* parenthesis denote number of locations in each district.

Table 3. Performance of improved and local chickpea varieties in on-farm trials in Nepal, 1991/92.

District/ Location	Plant stand 10 m^{-2}		Yield (t ha^{-1})		Increase in yield over local variety (%)
	Improved variety	Local variety	Improved variety	Local variety	
Banke (5)[1]	102	74	1.38	0.71	95
Bardia (5)	130	112	2.02	1.56	29
Sarlahi (4)	65	46	1.20	0.81	49
Mean	101	80	1.56	1.04	50

1. Figures in parenthesis denote number of locations in each district.

Wilt-resistant varieties were superior in yield over local varieties and gave an overall yield advantage of 68% (Table 4).

In Nepal, farmers generally allow weeds to grow in chickpea and pigeonpea fields and uproot them for forage purpose. Vigorous weed growth causes considerable yield losses in these crops. Weeded plots produced 8-34% more grain yield than the unweeded plots at Banke and Bardia (Table 5). Weed population was negligible in Sarlahi district and there was no difference in yield of weeded and unweeded plots.

Table 4. Wilt incidence and grain yield of wilt-resistant and local chickpea varietie in on-farm trials in Nepal, 1991/92.

District/ Location	Plant stand 10 m^{-2}		No. of wilted plants 10 m^{-2}		Yield (t ha^{-1})		Increase in yield over local variety (%)
	Wilt-resistant variety	Local variety	Wilt-resistant variety	Local variety	Wilt-resistant variety	Local variety	
Banke (4)[1]	108	55	NR[2]	NR	1.78	0.61	190
Bardia (4)	115	137	NR	NR	1.82	1.62	13
Sarlahi (4)	55	54	0	4	1.50	0.96	88
Mean	97	82	0	1	1.78	1.01	68

1. Figures in parenthesis denote number of locations in each district.
2. Not recorded.

Table 5. Effect of weed control on grain yield of chickpea in on-farm trials in Nepal, 1991/92.

District/ Location	Plant stand 10 m^2		No. of weed plants 10 m^2		Yield (t ha^{-1})		Increase in yield over unweeded plots (%)
	Hand weeding	No weeding	Hand weeding	No weeding	Hand weeding	No weeding	
Banke (4)[1]	119	108	9.3	53	1.25	1.16	8
Bardia (4)	116	125	12	182	2.06	1.52	34
Sarlahi (4)	65	56	NR	NR[2]	1.22	1.24	
Mean	100	96	10.6	117.5	1.51	1.32	15

1. Figures in parenthesis denote number of locations in each district.
2. Not recorded.

Pigeonpea

Trials on pod borer and pod fly control were conducted with the variety Bageshwari in Sarlahi district and with ICPL 366 in Banke and Bardia districts. At Sarlahi, pigeonpea seed was dibbled and intercropped with groundnut (one or two rows of pigeonpea and one row of groundnut) while it was broadcast in Banke and Bardia districts. Two plots (sprayed and unsprayed) were maintained at each location to evaluate the effect of insecticide treatments. The first spraying was done with dimethoate (Rogor® 25 EC at the rate of 1.5 1 ha^{-1}) at early pod forming stage. Thiodan® (2.0 1 t ha^{-1}) was also sprayed at early pod forming stage. Rogor® (1.5 1 ha^{-1}) was again sprayed 10-12 days after the second spraying. At all test sites the unsprayed plots had higher pod damage both from podfly and pod borer compared with the sprayed plots

(Table 6). The yield was also low in control plots (1.16 t ha^{-1}) compared with that c the sprayed treatment (1.52 t ha-^{1}).

The comparison of sterility mosaic (SM) resistant varieties—Bageshwari and ICP 366—with the local susceptible varieties was done at Sariahi, Banke, and Bardi districts. The SM incidence was low, therefore the real advantage of sterility mosai resistant varieties could not be evaluated. However the yield advantage of improve varieties over local variety was clearly apparent (Table 7). The recently release variety, Bageshwari, produced on average 44% higher yield (1.66 t ha^{-1}) than the loca variety (1.16 t ha^{-1}).

Stem canker is known to cause severe damage to pigeonpea in Nepal. Sine resistant genotypes are yet to be identified, chemical control was attempted throug the application of Bavistin®. Four trials each were planted in Banke, Bardia, an Sarlahi districts. The disease incidence in these trials was very low, hence fungicid treatments were not imposed.

Table 6. Effect of chemical control on damage (%) by podfly and pod borer and mean grain yield of pigeonpea in Nepal, 1991/92.

District Location	Plant stand 10 m^{-2}		Podfly damage (%)		Pod borer damage (%)		Yield (t ha^{-1})		Increase in yield
	Sprayed	Un-sprayed	Sprayed	Un-sprayed	Sprayed	Un-sprayed	Sprayed	Un-sprayed	over un-sprayed plots (%)
Banke (4)'	21	19	10.3	23.2	8.1	15.8	1.76	1.36	30
Bardia (4)	74	75	6.3	13.9	5.4	14.8	1.57	1.29	22
Sarlahi (4)	88	77	9.1	13.5	14.1	21.2	i.22	0.83	47
Mean	61	57	8.4	16.6	9.2	17.2	1.52	1.16	31

1. Figures in parenthesis denote number of locations in each district.

Table 7. Mean performance of sterility mosaic resistant pigeonpea varieties in on-farm trials in Nepal, 1991/92[1].

Varieties	Sarlahi district			Banke district			Bardia district			Mean			
	Plant stand (plants 10 m^{2})	In-fected plant (%)	Yield (kg ha^{1})	Plant stand (plants 10 m^{2})	In-fected plant (%)	Yield (t ha^{1})	Plant stand (plants 10 m^{2})	In-fected plant (%)	Yield (t ha^{1})	Plant stand (plants 10 m^{2})	In-fected plant (%)	Yield (tha^{1})	In. crease over local control (%)
Bageshwari	23	-[2]	154	110	-	179	66		1 66	66		1 66	44
ICPL 366	14	25	0 77	111	-	144	70		135	65	0-2 5	119	3
F Local	16	20	081	89	21	142	61		1 25	55	0-2 0	116	

1 Trials were conducted at four locations in each district

2 Indicates no disease incidence

Farmers' Reaction and General Observations

- Most farmers who conducted the on-farm trials in 1991/92 were eager to repeat them again in 1992/93, indicating the success of these trials in the first year.
- AGLOR trials created an awareness among farmers about the economic value of chemical control of pod borer in chickpea, pod borer, and pod fly in pigeonpea and the importance of improved disease-resistant varieties of chickpea and pigeonpea.
- The project has provided opportunities for local scientists to learn the methodology of on-farm research and facilitated interactions among the national research and extension staff.

Future Plans

On the basis of the results obtained from single factor treatment comparisons in 1991/92 an improved package of practices was developed (Table 8). This package will be compared with the local farmers' practices in on-farm trials in 1992/93.

Table 8. Proposed set of improved package of practices for chickpea and pigeonpea on-farm research trials in Nepal for 1992/93.

Component	Chickpea	Pigeonpea
Variety	Dhanush and Kajika for Sarlahi district Kalika and Kosheli for Banke and Bardia districts	Bageshwari for all districts. Additionally, ICPL 87133 and ICPL 84072 (with wilt and sterility mosaic resistance) to be tested in Banke and Bardia.
Seed treatment	1:1 Thiram + Bavistin® (3 g kg^{-1} seed)	1:1 Thiram + Bavistin® (3 g kg^{-1} seed)
Fertilizer	None recommended	10:20:0 N, P_2O_5, K_2O kg ha^{-1}
Weed control	Two hand weedings at 25 and 45 days after sowing	Two hand weedings at 30 and 50 days after sowing
Insecticide sprays	Thiodan® (2 L ai ha^{-1}) at flowering stage Decis® (2 Lai ha^{-1}) at pod fill stage.	Rogor® (1-1.5 L ai ha^{-1}) at 50% flowering stage Thiodan® ((2 L ai ha^{-1}) at early pod formation stage Rogor® (1-1.5 L ai ha^{-1}) 10-15 days after second spray

Conclusion

At many locations the improved chickpea cultivars, Sita, Kalika, and Dhanush, and pigeonpea cultivars Bageshwari and ICPL 366 were superior to local cultivars in seed yield. The real advantage of disease-resistant varieties compared with local varieties could not be established due to low incidence of diseases in the test season. Because of generally high wilt incidence in the local pigeonpea varieties, future on-farm trials should include cultivars with combined resistance to wilt and sterility mosaic. The advantages of seed dressing, weed control, and control of insect pests should be effectively disseminated to farmers.

Botrytis grayanold and wilt in chickpea, and sterility mosaic and wilt in pigeonpea are the major biotic constraints in Nepal, therefore research work should be further strengthened to overcome these diseases. The development of resistant varieties will help to increase the area and production of both crops in Nepal.

Reference

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Nepal (Groundnut)

B.P. Sharma and G.P. Koirala[1]

Introduction

The Land Resources Mapping Project of Nepal in 1986 estimated 572 000 ha as potential area for groundnut in the country. In spite of this tremendous potential for increase in area, groundnut continues to be a minor oilseed crop in Nepal.

During the early 1980s there was only one hydrogenation plant in Nepal, at Hetauda, with a capacity of 6000 t per year. At present there are about a dozen such oil-refining or processing plants with a capacity of about 85 000 t per year. There has been a large demand for oilseed crops from the vegetable oil-refining industries in the country. However, over the years, the area under groundnut cultivation has not shown any significant increase.

After the establishment of the National Oilseeds Research Program, packages of practices for realizing maximum groundnut yield were developed. But, mere development of high production technology does not solve the problem unless it is transferred to, and adopted by, farmers. The Asian Grain Legumes On-farm Research (AGLOR) Project, started in collaboration with ICRISAT, was aimed at increasing yield levels by technology transfer using an on-farm research approach.

Target Areas for Diagnostic Survey

Five groundnut-growing districts (Sarlahi, Nawalparasi, Sunsari, Rauthat, and Bara) were chosen for on-farm research. All of these districts are in the *Terai* region. Annual rainfall in the *Terai* averages 1600 mm. Most of the annual rainfall (60-80%) is received during monsoon (Jun to Sep). Mean temperatures in the *Terai* range from about 14° C in Jan to about 36°C in Jul-Aug. In general, soils are alluvial sandy to loamy, and coarse sandy to medium sandy with low organic matter.

Reasons for Low Yields

The target areas are characterized by poor farmers with small land holdings. The most common constraints to increased production are:

- Uncertainty of rains at the time of sowing;
- Nonavailability of seed of improved variety with desirable maturity;

1. National Oilseeds Research Program, Nawalpur, Sarlahi, Nepal.

- Very low plant density;
- Insect pests causing major yield losses (termites followed by foliage-eating caterpillars); and
- Little or no use of fertilizers.

On-farm Research Trials

Based on the constraints identified by farmers, scientists formulated a set of trials. There were eight single-factor trials (farmers' practice + one improved treatment vs farmers' practice alone). Details of the treatment factors are given in Table 1. Plot size per treatment was 0.5 *katta* (166.5 m^2). Each of the single-factor trials was conducted in three to four farmers' fields at each village/site.

Table 1. List of single-factor diagnostic treatments for groundnut on-farm research in Nepal, 1991/92.

Trial	Treatment	Purpose
Seed dressing fungicides	Thiram + Bavistin® (50:50), 3 g kg^{-1} (just before sowing)	To determine if seedling disease is a constraint
Seed dressing insecticide	Chloropyriphos (12.5 $mLkg^{-1}$ seed)	To determine if soil insects (white grubs) reduce plant stand
Rhizobium	NC 92 *Rhizobium* culture	To see if *Rhizobium* can improve pod yield, particularly in rice fallows
Foliar disease control	Daconil® (chlorothalonil) 50-60 DAS or when around 10 spots $plant^{-1}$ appear	To determine if foliar diseases might be a constraint
Insect pest control	Folithan®/Sumithion® 0.5% at 40 days or when insects are present	To determine if insect pests are a problem
Micronutrient spray	Tracel® spray, 30 DAS	To determine if micronutrient deficiency reduces yield
Seed rate/spacing	80 kg ha^{-1}; 40x20 cm	To observe the effect of plant population on pod yield
Gypsum	400 kg ha^{-1} at peak of flowering. At second weeding, placed near base of plant on both sides of a row	To determine the role of gypsum in pod filling and pod yield

Results

Results from on-farm trials in 1991 indicated the possibility of increasing groundnut pod yield by various management practices (Table 2), although beneficial effects of these treatments varied across locations.

Table 2. Effect of individual treatments on pod yield (kg ha^{-1}) of groundnut in farmers' field of different villages, Nepal, Jun-Oct 1991.

Treatment factors	Babarganj			Laukat			Piparpati		
	(+)	(-)	Increase over FP[1] (%)	(+)	(-)	Increase over FP (%)	(+)	(-)	Increase over FP (%)
Seed treatment with fungicide	1.66	1.53	8	1.36	1.13	20	1.96[2]	2.24	
Seed treatment with insecticide	1.67	1.58	6	1.56	1.24	26	2.18	1.89	16
Rhizobium inoculation	1.38	1.24	11	1.63	1.22	33	2.49	2.29	9
Phosphorus fertilizer	1.46	1.34	9	1.36	1.21	12	2.30	1.68	38
Kavach® spray	1.76	1.67	5	1.37	1.51		1.45	1.24	17
Recommended spacing	1.62	1.38	17	1.58	1.15	38	2.24	1.60	41
Gypsum application	1.96	1.78	11	1.72	1.24	38	1.99	1.89	5
Varietal evaluation									
B4	1.65			NA[3]			2.22		
ICGS (E) 56	1.97			1.06			1.86		
Local	NA			1.36			2.11		

1. FP = Farmers' practice.
2. Low yield due to rat damage.
3. Variety not tested.

Effective treatments in the 1991 AGLOR trials were combined as an improved package of practices (IPP) of groundnut production and compared with traditional farmers' practice (FP) in 1992. These trials were conducted at eight villages of five *Terai* districts of Nepal. Improved package of practices increased pod yield by 15 to 42% over the farmers' practices (Table 3). The application of gypsum was effective in increasing seed size and shelling percent.

Disease and Pest Surveys

The following diseases were observed during a survey: yellow mold *[Aspergillus flavus),* crown rot (*Aspergillus niger),* early leaf spot *(Cercospora arachidicola),* late

Table 3. Effect of improved package of practices on groundnut production in eight sites in Nepal, Jul-Nov 1992.

Location/ Treatment[1]	Groundnut variety	Plant stand at harvest ('000 ha^{-1})	Pods $plant^{-1}$	Pod yield (t ha^{-1})	Shelling (%)	100 seed mass (g)
Harinagara						
IPP	B4	133	10.2	0.75	63.6	45.4
FP		105	7.8	0.62	60.4	43.0
Increase over FP (%)		26	30.8	21.4	3.2	5.6
Madhaharsahi						
IPP	B 4 and Janak	135	9.5	0.49	74.2	56.2
FP		119	5.7	0.41	69.8	52.0
Increase over FP (%)		13	66.7	21.5	4.4	8.1
Babarganj						
IPP	ICGS(E) 56	87	29.6	0.95	73.1	39.6
FP		78	27.5	0.83	72.2	38.4
Increase over FP (%)		12	8.4	14.6	0.9	3.1
Hazaria						
IPP	Janak	91	30.7	2.23	67.5	62.7
FP		81	26.3	1.85	63.3	58.5
Increase over FP (%)		11	16.7	20.5	4.2	7.2
Manpur						
IPP	Janak	103	24.8	2.05	65.8	58.0
FP		98	20.0	1.51	63.0	53.0
Increase over FP (%)		4	24.0	35.5	2.8	9.4
Shivanagar						
IPP	B4	114	33.0	2.29	75.0	46.9
FP		98	30.6	1.61	74.4	43.2
Increase over FP (%)		16	7.8	41.7	0.6	8.6
Jitpur						
IPP	Janak	93	35.0	2.65	57.2	77.2
FP		78	29.0	2.14	55.5	72.0
Increase over FP (%)		20	20.7	23.6	1.7	7.2
Piparpati						
IPP	Janak	95	29.8	1.48	61.7	47.5
FP		76	20.0	1.10	54.5	39.5
Increase over FP (%)		25	40.0	34.4	7.2	20.3

1. IPP = improved package of practices, FP = farmers' practices.

leaf spot *(Phaeoisariopsis personata),* rust *(Puccinia arachidis)* and bud necrosis disease (BND). Among these, BND incidence in Harinagara and Madhaharsahi, early leaf spot and rust in Babarganj, late leaf spot in Jitpur and Piparpati were found to be very serious (Table 4).

The important insect pests observed in groundnut fields were termite *(Odontotermes* sp.), white grub (*Lachnostarna* sp.), thrips *(Scirtothrips dorsalis* Hood), jassid (*Empoasca* sp.), leaf miner *(Aproaerema modicella),* spodoptera *(Spodoptera litura)* and jute hairy caterpillar *(Diacrisia obliqua).* Among them termite, thrips, and jute hairy caterpillar were found to be very serious at Harinagara and Madhaharsahi, whereas jassid was a major problem at Manpur (Table 5).

Table 4. Major diseases[1] of groundnut in AGLOR trials of five *Terai* districts of Nepal, Jul-Nov1992.

Location	Yellow mold	Crown rot.	Early leaf spot	Late leaf spot	Rust	BND
Harinagara	*	*	* *		* *	* **
Madhaharsahi	*	*	*	* *	* *	* * *
Babarganj	*	*				
Hazaria	* *	**		**	* *	* *
Manpur	* **	**	* *	* *	* *	* *
Shivanagar	*	* *		* *	* *	* *
Jitpur	*	*	*		* *	*
Piparpati	*	*	*	* * *	* *	«

1. * Less important, ** important; *** very important.

Table 5. Major insect pests[1] of groundnut in AGLOR trials of five *Terai* districts of Nepal, Jul-Nov 1992.

Location	Termite	White grub	Thrips	Jassid	Leaf miner	Spodop-tera	Jute hairy caterpillar
Harinagara	***	-[2]	***	* *	-	-	* * *
Madhaharsahi	** *	-	* * *	* *	-	-	** *
Babarganj	*	*	*	*	-	-	-
Hazaria	**	-	**	* *	-	-	-
Manpur	**	-	* *	* * *	-	-	-
Shivanagar	*	*	*	* *	-	-	-
Jitpur	*	-	*	*	-	-	-
Piparpati	*	-	*	*	-	-	-

1. * Less important; ** important; *** very important.
2. Not recorded.

Farmers' Reaction and General Observations

- Farmers have realized the importance of individual as well as combined treatments as improved practices.
- The area under groundnut cultivation at Piperpati of Nawalparasi district increased in 1992 compared with that in 1991, because of AGLOR trials.
- Most of the farmers liked short-duration groundnut varieties. Farmers of Manpur and Hazaria preferred the B 4 Virginia bunch type for easy harvesting, whereas a few farmers demanded confectionery type 'Janak' variety.
- Single spray of Kavach® did not control the foliar diseases significantly.
- There was a large demand for quality seeds of groundnut.

Future Research Plan

Testing of the improved package of practices will be extended to involve more farmers in different villages. Socioeconomic studies will be conducted to evaluate benefits of improved packages and rate of adoption by farmers. The set of improved package of practices that was formulated is as follows:

- Varieties: B 4, Janak, and ICGS(E) 56.
- Fertilizer: 20:40:20 ($N:P_2O_5:K_2O$) kg ha^{-1} (basal).
- Row/plant spacing: 40 x 20 cm (for Janak) and 40 x 10 cm (for B 4 and ICGS(E) 56).
- Seed treatment: (a) 1:1 Thiram + Bavistin® (3 g kg^{-1} seed) and (b) chlorophyriphos (8-10 mL kg^{-1} seed).
- *Rhizobium* inoculation: liquid application in furrows just before sowing.
- Gypsum: 400 kg ha^{-1} at peak flowering stage.
- Micronutrients: one spray (of Swarnafal® or Agromin®) at 30 DAS.
- Foliar disease control: Daconil® or Kavach® (Chlorothalonil) (1.6 kg in 800 L of water ha^{-1}), (a) Janak and B 4: first spray at 50-60 DAS followed by a second spray 15 days after first spray; (b) ICCS(E) 56: first spray at 40 DAS followed by a second spray 15 days after the first spray.
- Pest control: spray based on threshold levels for pests (maximum of 3 sprays).

Sri Lanka

S.N. Jayawardena[1], S. Parthipan[1], K.D.S.M. Joseph[1], and P.B. Jayamanne[2]

Introduction

Agriculture in Sri Lanka plays a vital role in its economy. It provides 79% of the total export earnings and 25% of the GDP, generates 20% of the government revenue, and employs 40% of the labor force of the country. Based on the annual rainfall, the country is divided into three major climatic zones: wet, intermediate, and dry zones. The wet zone which is about 1.5 million ha in extent receives rainfall of 1800-5000 mm per annum. The dry zone (4.1 million ha) and the intermediate zones (0.88 million ha) receive 875-1800 mm of rainfall. The rainfall pattern is bimodal.

It is estimated that about 60% of rice and 80% of food grains, grain legumes, and vegetables are produced in the dry zone. This indicates the importance of the dry zone in the production of country's food requirements. Rice is grown in lowland in both major *(Maha)* and minor *(Yala)* rainy seasons with supplementary irrigation.

Some on-farm research and demonstrations on groundnut and pigeonpea have been carried out during the last two seasons. This paper discusses the results obtained from these studies.

Agroclimatic Features of the Dry Zone

All the demonstrations and research areas of groundnut and pigeonpea were mainly confined to the dry zone of the country. The rainfall in the area is bimodal. One peak occurs in Apr-May (*Yala* season) and the other in Oct-Nov *(Maha* season). The annual average rainfall in most of the areas is around 1200 mm. The predominant soil group in the dry zone is Alfisols. These soils have low water-holding capacity and harden quickly after rain. The non-calcic brown soils in the east coast are low in fertility.

Investment made by farmers on rainfed upland crops in the dry zone is very little compared with the investment on irrigated crop production. This is mainly due to the risk associated with cultivation under rainfed conditions.

Pigeonpea

Pigeonpea is a reintroduced crop to Sri Lanka. There is a great potential for this crop, as it is capable of withstanding drought and can be used as a substitute for imported lentil.

1. Regional Agriculture Research Centre, Maha Illuppallama, Sri Lanka.
2. Regional Agriculture Research Centre, Angunakolapelessa, Sri Lanka.

A series of experiments conducted on adaptation of ICRISAT's short duration, high-yielding pigeonpea varieties at the Agricultural Research Centre, Maha Illuppallama, and farmers' fields have clearly demonstrated that this crop can be grown successfully in many parts of the country.

On-farm Research on Pigeonpea

Varietal Evaluation

Four pigeonpea varieties were tested at 7 locations in Anuradhapura district for adaptability under farmers' conditions. The yields obtained ranged from 680 to 1892 kg ha^{-1}. The variety ICPL 2 recorded the highest mean yield (Table 1). Some farmers preferred ICPL 2 and ICPL 84045 as the pest damage was low in these varieties, while others preferred ICPL 87 as it was found suitable for spraying.

Table 1. Yield (kg ha^{-1}) of four pigeonpea varieties grown in different locations in Anuradhapura district under rainfed conditions, 1991/92 *Maha* season, Sri Lanka.

	Yield			
Location	ICPL 87	ICPL 84045	ICPL 88026	ICPL 2
Iththaawewa-1	1611	1875	1236	1875
Iththaawewa-2	1856	1616	1926	1892
Teppankulama	851	680	1083	1458
Moragoda	855	883	1197	1215
Anduketiyawa	867	1071	918	1020
Ihalawewa	1733	1170	1182	1573
Yahalegama	1345	1630	1252	1770
Mean yield (kg ha^{*1})	1302	1268	1263	1543
Days to maturity (mean)	107	121	107	117
Plant height (cm)	108	174	126	184

(Source: Adaptive Research Report 91/92 *Maha* season, Regional Agricultural Research Centre, Maha Illuppallama, Sri Lanka).

On-farm Demonstrations

Approximately 50 ha of pigeonpea were cultivated as demonstrations during the 1990/91 *Maha* season in Kurunegala, Anuradhapura, and Matale. The varieties used were ICPL 2, ICPL 161, and ICPL 87. Yields ranged from 25 to 3075 kg ha^{-1} (Table 2). Low yields at some locations were mainly due to pest damage. In addition, a number of mini demonstrations of 0.1 ha each were conducted by the Peoples' Participation Program. The average yield obtained under these mini demonstrations were 1362 kg ha^{-1} for ICPL 87 and 1166 kg ha^{-1} for ICPL 2.

Three promising, high yielding, short-duration varieties were evaluated in 57 farmers' fields in four districts (Table 3). The variety ICPL 87 gave better yields than ICPL 84045 and ICPL 2. Average yields reported here are lower than actual yields because the yield data were estimated on values given by farmers. Some of the farmers had consumed part of the pigeonpea when yields were estimated.

Table 2. Average yield of pigeonpea in on-farm demonstrations during the 1990/91 *Maha* season in three districts, Sri Lanka.

District	No. of farmers	Area (ha)	Yield ($kg\ ha^{-1}$) Average	Range
Kurunegaia	56	18	927	140-3705
Anuradhapura	57	18	666	375-2250
Matale	45	12	820	25-1875

(Source: Pigeonpea varietal adaptation and production studies in Sri Lanka, 1992).

Table 3. The average yield (kg ha[1]) of three high-yielding pigeonpea varieties in the on-farm demonstrations during the 1991/92 *Maha* season, Sri Lanka.

	Yield ($kg\ ha^{-1}$)					
	ICPL 87		ICPL 84045		ICPL 2	
District	Average	Range	Average	Range	Average	Range
Anuradhapura	374	104-648	223	164-304	222	-[1]
Kurunegala	430	152-680	190	112-320	256	164-368
Polonnaruwa	-	-	149	40-480	-	-
Matale	-	-	188	-	249	108-492

1. Not recorded

(Source: Regional Agricultural Research Centre, Maha Illuppallama.)

Economic Survey

The major cost component for pigeonpea cultivation was labor. This is mainly due to increased number of sprayings and other labor-intensive operations such as harvesting and threshing (Table 4). Profits from pigeonpea cultivation were good. Even though pigeonpea required a little longer period to mature than some other legume crops grown by farmers, it can be considered as a suitable crop in the cropping systems of rainfed farming in the dry zone of Sri Lanka, due to its ability to withstand drought.

The survey tried to ascertain farmers' perception of the advantages and disadvantages of pigeonpea. The major advantages appear to be drought tolerance, suitability for marginal lands, less weed problems, and good taste. However, farmers need knowledge on its cultivation practices and pest management. Problems related to marketing and processing into *dhal* were also expressed by the farmers. These are now being addressed by the government and private industry to make the pigeonpea cultivation profitable.

Table 4. Returns and profitability of pigeonpea cultivation in the 1990 *Maha* and the 1991 *Yala* seasons, Sri Lanka.

Parameters	Main crop	Ratoon crop
Average farm size (ha)	0.18	0.18
Total man-days needed for cultivation	220	80
Average yield (kg ha^{-1})	886	349
Gross income (Rs ha^{-1})[1]	24 280	9 650
Total cost (Rs ha^{-1})	18 154	6 751
Cost excluding family labor (Rs ha^{-1})	8 305	2 960
Profit including cost of family labor (Rs ha^{-1})	6 126	2 809
Profit excluding cost of family labor (Rs ha^{-1})	15 975	6 600

1. 1 $ US = 48 Sri Lankan Rupees.

(Source: Agricultural Economics Division, Department of Agriculture, Sri Lanka).

Groundnut

Groundnut has been grown in Sri Lanka for several decades. After 1980 there was an increase in groundnut production in the country mainly due to increase in area cultivated. However, the average yield of the crop remained unchanged during this period (Table 5).

Table 5. Area, production, and average yield of groundnut in Sri Lanka, 1975-91.

Year	Area ('000 ha)	Production ('000 t)	Mean yield (t ha^{-1})
1975	7.78	7.62	0.98
1976	6.73	6.09	0.91
1977	6.48	5.70	0.88
1978	8.28	7.48	0.90
1979	5.34	5.44	1.01
1980	9.54	14.06	1.47
1981	12.67	14.47	1.20
1982	14.36	14.75	1.03
1983	13.77	18.93	1.37
1984	7.62	6.52	0.86
1985	7.99	8.32	1.04
1986	10.25	9.83	0.96
1987	9.46	17.75	1.99
1988	12.53	11.91	0.95
1989	10.34	8.83	0.85
1990	10.98	11.12	1.01
1991	10.14	11.47	1.13

(Source: Agricultural Economics Division, Department of Agriculture, Sri Lanka.)

Diagnostic Survey

Surveys were carried out to determine production constraints and ways to improve the existing methods of groundnut cultivation. The surveys were jointly conducted by the Department of Agriculture and ICRISAT. Results revealed that groundnut yield was much below its potential due to the poor management conditions associated with the risky environment. Several constraints were identified:

- Moisture stress;
- Lack of quality seeds;
- Pests (including wild animals) and diseases;
- Lack of improved production technology;
- Unstable prices; and
- Lack of transport facilities.

Based on the survey, the scientists prepared a set of diagnostic trials to compare different treatments with farmers' practices.

Diagnostic On-farm Experiments

Seven diagnostic treatments were compared individually with farmers' practices during the 1991/92 *Maha* season in Kurunegala and Hambantota districts (Table 6). Low

Table 6. Pod yields of groundnut in different on-farm diagnostic trials during 1991/92 *Maha* season, Kurunegala and Hambantota districts, Sri Lanka.

	Pod yield (t ha^{-1})		
Treatments	Kurunegala	Hambantota	Mean
Plowing			
With	1.55	2.33	1.94
Without	2.31	1.73	2.02
Seeds per hill			
I seed	1.38	2.03	1.71
3 seeds	0.43	1.16	0.80
Seed treatment			
Treated	1.88	1.84	1.86
Control	1.27	2.06	1.66
Foliar spray (Mancozeb)			
Sprayed	0.92	2.29	1.61
Control	0.76	1.54	1.15
Earthing up			
Earthing up	1.89	3.41	2.65
Control	2.08	1.88	1.98
Fertilizer			
Applied	0.30	1.97	1.13
Control	0.40	2.23	1.32
Variety			
ICGS 11	1.09	2.33	1.71
Local	0.89	2.01	1.45

yields were recorded due to termite damage and low plant populations in some farmer's fields. Although, concrete conclusions cannot be drawn from these results, it appears that some of the treatments, e.g. improved variety ICGS 11 and foliar spray with Mancozeb, showed encouraging results. The same experiments conducted at the Regional Agricultural Research Centre, Angunakolapelessa, showed similar results (Table 7).

Table 7. Pod yields of groundnut in different diagnostic trials at Angunukolapelessa Research Centre during 1991/92 *Maha* and 1992 *Yala* seasons, Sri lanka.

	Pod yield (t ha^{-1})		
Treatments	1991/92 *Maha*	1991 *Yala*	Mean
Plowing			
With	1.22	1.82	1.52
Without	1.19	1.46	1.33
Seeds per hill			
1 seed	1.20	1.19	1.19
3 seeds	1.70	1.79	1.75
Seed treatment			
Treated	0.92	1.69	1.31
Control	1.12	1.61	1.36
Foliar spray (Mancozeb)			
Sprayed	1.14	2.02	1.58
Control	1.03	1.73	1.38
Earthing up			
Earthing up	1.17	1.61	1.39
Control	1.15	1.60	1.37
Fertilizer			
Applied	1.13	1.93	1.53
Control	1.17	1.61	1.39
Variety			
ICGS 11	).2()	2.82	2.01
Local	1 09	1.99	1.54

The seven diagnostic treatments were also evaluated in Anuradhapura, Kurunegala, and Vavunia *districts* in the 1992 *Yala* season (Table 8). In this season too, low yields were recorded in Kuiunegala and Anuradhapura districts due to pod borer and termite damage. Seed treated with Captan gave higher yields in all three districts. ICGS 11 performed better in Anuradhapura and Vavunia districts.

Table 8. Pod yields of groundnut in different diagnostic on-farm trials during 1992 *Yala* season in three districts of Sri Lanka.

	Pod yield ($t\ ha^{-1}$)			
Treatments	Anuradhapura	Kurunegala	Vavuniya	Mean
Plowing				
With	0.58	1.28	1.92	1.26
Without	0.22	1.90	1.53	1.22
Seeds per hill				
1 seed	0.48	1.64	1.44	1.19
3 seeds	0.34	1.58	1.96	1.29
Seed treatment				
Treated	2.01	0.80	4.56	2.46
Control	1.37	0.64	3.04	1.68
Foliar spray (Mancozeb)				
Sprayed	-[1]	1.62	3.60	2.61
Control		2.22	2.96	2.59
Earthing up				
Earthing up	1.08	1.36	2.83	1.76
Control	1.01	1.55	2.65	1.74
Fertilizer				
Applied	0.72	0.30	2.96	1.33
Control	0.57	0.38	2.66	1.20
Variety				
ICGS 11	1.24	1.62	3.38	2.80
Local	0.78	1.75	2.08	1.78

1. Not recorded

Conclusion

Results from the on-farm trials have been inconsistent mainly due to problems with plant stand and poor management. In both seasons the improved variety ICGS 11 performed well at most locations. Seed treated with Captan as well as spray with Mancozeb, gave higher yields at some locations. One seed per hill has been found to produce yields equal to 3 seeds per hill. Our experiences from the groundnut on-farm research program during the last two seasons show that the average yield (1000 kg ha^{-1}) can be increased up to 1500-2000 kg ha^{-1} with the use of high-yielding varieties and good management practices. In future, a combination of treatments found to increase yield in these trials will be compared with farmers' practices.

Vietnam

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Introduction

Groundnut is the most important legume crop in Vietnam. Average cropping area under groundnut in Vietnam is around 200 000 ha, which is equally distributed between the north and the south of the country. At present, groundnut is popularly used in various ways as food and feed. It also plays an important role as one of the major export commodities of Vietnam. However, groundnut yields in Vietnam remain low at around 11 ha^{-1}, leading to low economic returns and stagnant production. To improve groundnut production, it is necessary to identify the key constraints responsible for the generally low yields of this crop and to find appropriate solutions to overcome these constraints.

In the framework of UNDP/FAO RAS/89/040 and ICRISAT/MAFI collaboration, the Asian Grain Legumes On-farm Research (AGLOR) project has been implemented from early 1991 to help Vietnam tackle these problems and to improve groundnut production in the country. This report reviews the activities of the AGLOR Project and the results obtained during 1991 and 1992.

Diagnostic Surveys on Constraints to Groundnut Production

In Feb 1991, diagnostic surveys were conducted in major groundnut-growing areas of both northern and southern Vietnam to identify major constraints to groundnut production. Nghe Tinh and Ha Bac in the north, and Tay Ninh and Long An in the south, the four largest groundnut-growing provinces of Vietnam, were selected as target areas for AGLOR.

The main characteristics of the surveyed provinces are given in Table 1. Nghe Tinh province, which was recently divided into Nghe An and Ha Tinh provinces, is located in the north-central part of Vietnam. Ha Bac province is located north of Hanoi. In both Ha Bac and Nghe Tinh provinces, groundnut is grown mostly in spring (Feb-Jun), In high elevation areas (midland and sloping areas), it is also cultivated in autumn (Jul-Nov), mainly for seed production for the spring season crop.

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Table 1. Main characteristics of provinces in Vietnam in which the Asian Grain Legume On-farm Research (AGLOR) activities have been conducted.

Province	Location (°N)	Cultivated area of (ha)	Mean annual (mm)	Monthly temperature range (°C)	Major soil types	Main cropping season of groundnut
Nghe Tinh	18-20	29 000	2060	17.3-29.5	Sandy, sandy loam	Feb-Jun
Ha Bac	21-22	22 000	1750	13.0-29.0	Alluvial red soil, degraded soil	Feb-Jun
Tay Ninh	11-12	19 000	1910	24.9-28.8	Alluvial gray soil, sandy, sandy loam	Nov-Mar
Long An	10-11	11 000	1520	26.0-29.5	Acid sulphate soil	Nov-Mar

Both Tay Ninh and Long An provinces in southern Vietnam have a tropical monsoon climate. The rainy season is from May to Oct and the dry season from Nov to Apr. Groundnut is grown mainly in the winter-spring season (Nov-Mar) with irrigation, but also in summer (Jun-Oct).

Diagnostic surveys were conducted in selected districts and cooperatives of these four provinces. Details of the survey methods used are given in a paper by Gowda et al. (1993). They were selected on the basis of groundnut area cultivated, possibilities for expansion of area, and discussions with the agricultural department staff.

Survey Results

Based on the information obtained from interviews with farmers, the survey team prioritized the constraints to groundnut production in the target areas (Table 2). Lack of cash for inputs was identified as a major constraint by all farmers. Unstable and low price of groundnut was also identified as an important socioeconomic constraint in northern Vietnam. Among biotic constraints, lack of high yielding varieties with suitable maturity period and resistance to major diseases and pests was a first priority problem. Leaf-eating insects, soilborne and foliar diseases, and weeds were also identified as constraints by farmers.

Plan for On-farm Trials

The identified socioeconomic problems need to be primarily addressed by the province and district administrations through policy decisions. Based on the prioritized

Table 2. Constraints to groundnut production in the major groundnut-growing provinces of Vietnam.

	Priority ranking[1]			
Constraints	Nghe Tinh	HaBac	Tay Ninh	Long An
Socioeconomic				
Lack of cash for inputs	1	1	1	1
Unstable/low price of groundnut	2	1		3
Lack of drainage system	2	3		
Lack of irrigation water	2	2	3	2
Abiotic				
Poor soil fertility		2		
Drought	3	2		
Biotic				
Lack of high-yielding varieties	2	1	1	1
Leaf eaters/other insect pests	2	2	1	1
Soilborne diseases	2	3	2	2
Foliar diseases	3	2	2	2
Yellow leaf disease	3		3	3
Weeds			2	2

1.1 = high, 2 = intermediate, and 3 = low priority, - = constraint not identified.

abiotic and biotic constraints, a plan for on-farm trials to address these problems was formulated (Table 3).

For on-farm experiments in northern Vietnam, high priority was given to: *Rhizobium* inoculation to augment nitrogen supply of the degraded and poor soils; lime application to improve the soil and supply nutrients; and seed and soil treatments and chemical sprays to control major diseases and pests.

Table 3. On-farm trials designed to address the identified constraints to groundnut production in Vietnam.

Experiments	Nghe Tinh	HaBac	Tay Ninh	Long An
Lime application	+[1]	+	+	+
Rhizobium inoculation	+	+	+	+
Split application of N	-	-	+	+
Spacing, number of seeds $hill^{-1}$	-	-	+	+
Foliar disease control	+	+	+	+
Insect pest control	+	+	+	+
Seed treatment with chemicals	+	+	+	+
Seed and soil treatment	+	-	-	-
Purification of local varieties	-	-	+	+
Spray of Fe_2SO_4 + urea in yellow patches	-	-	+	+
Superphosphate application	-	-	+	+
Mechanization	-	-	+	+

1. + = trial conducted, - = not conducted.

In southern Vietnam, considering the already high yield level obtained by farmers (average farmers harvest up to 1.5 t ha-^{1}, while good farmers harvest over 2.5 t ha^{-1}) there was a need for fine tuning of the technology to increase its effectiveness. Emphasis was given to reallocation of input costs to maximize profits to farmers. For on-farm trials in southern Vietnam, high priority was given to optimum spacing, split application of nitrogen, seed treatment, and control of major pests and diseases.

All the on-farm trials were conducted in farmers' fields. The farmers laid out the experiments in their fields with the guidance of researchers and extension personnel. Experimental plot sizes varied depending on land availability and number of treatments in a trial. In northern Vietnam, they were in the range of 80-200 m^2. In southern Vietnam, the range of plot sizes was 50-100 m^2, except for the nitrogen application trial (10-100 m^2) and the fungicide trial (30-50 m^2). On control plots the farmers followed their usual cultivation practices. The farmers harvested groundnut from equal areas of each plot separately. Technology assessment was conducted through observation, sample and data collection during vegetative growth, and through comparison of dry pod yield of control and treatment plots.

Results of On-Farm Trials

Northern Vietnam

Lime application. Lirne application consistently increased pod yield of groundnut (Table 4). Split application of lime (200 kg ha^{-1} aS basal and 200 kg ha*^{1} at flowering), gave the highest yields, amounting to a 26% increase over the control (no lime) when averaged over five trial sites and two seasons,

Rhizobium *seed treatment.* Although the effect of *Rhizobium* inoculation varied from site to site, there was a significant effect of inoculation on pod yield at most sites (Table 4). Overall, inoculation increased pod yield by 15% over the control. Combination of *Rhizobium* inoculation with a basal application of 60 kg ha^{-1} urea increased groundnut pod yield by 24% on average.

Seed and soil treatments with chemicals. Treatment effects obtained were determined by incidence of soil insects and soil borne diseases (Table 4). Overall, seed treatment alone increased pod yield of groundnut by 11% while seed and soil treatments applied together increased yield by 19% in Nghe An province. Under high disease pressure, Bavistin® gave the most effective control, resulting in increased pod yield of up to 45%.

Foliar disease and pest control. Sprays of chemicals applied when necessary significantly reduced disease and pest incidence and increased groundnut yield (Table 4). Under high incidence of foliar diseases, two sprays of Daconil® increased pod yield by 24% compared with an unsprayed control. More than 20% yield increase was

Table 4. Effect of various treatments on dry pod yields of groundnut grown in the 1991 and 1992 spring seasons at different test sites of northern Vietnam. Yields in control plots (first row in each treatment) are shown together with treatment values as a percentage of the control (figures in parentheses are numbers of fields averaged).

	Nghe An province						Ha Bac province						
	Nghi Loc		Nam Dan		Dien Chau		Viet Yen		Tan Yen		Tien Son		
Treatment	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	Mean
Lime treatment													
Control yield (t ha^{-1})	2.10(3)	2.74(2)	1.83(3)	1.54(4)	1.77(4)	1.57(6)	1.06(4)	1.19(6)	1.10(3)	1.12(3)	-	-[1]	
400 kg ha^{-1} (basal)	140	111	107	116	100	110	-	111	-	112	-	-	113
200 kg ha^{-1} (at flowering)	-	111	-	109	-	115	116	111	115	110	-	-	112
200 kg ha^{-1} (basal) + 200 kg ha^{-1} (at flowering)	180	122	114	131	103	119	-	118	-	121	-	-	126
***Rhizobium* inoculation**													
Control yield (t ha^{-1})	2.00(3)	1.79(5)	1.89(3)	1.52(4)	-	1.76(6)	1.00(4)	1.10(6)	1.11(3)	1.08(3)	-	1.19(3)	
Inoculation	168	110	109	110	-	117	126	110	104	105	-	93	115
Inoculation + 60 kg ha^{-1} urea	-	128	-	117	-	128	-	-	-	-	-	-	124
Seed and soil treatment													
Control yield (t ha^{-1})	2.67(3)	2.09(3)	1.87(3)	1.55(4)	1.77(3)	1.64(6)	-	-	-	-	-		
Falizan® (1-2 g kg^{-1} seed)	100	107	105	107	125	121	-	-	-	-	-	-	111
Falizan® + Basudin (20-50 kg ha^{-1})	125	107	120	114	125	122	-	-	-	-	-	-	119
Bavistin® (1 g kg^{-1} seed)	-	-	-	-	-	145	-	-	-	-	-	-	
Thiram (1 g kg^{-1} seed)	-	-	-	-	-	130	-	-	-	-	-	-	
Sprays against foliar disease													
Control yield (t ha^{-1})	2.00(3)	2.05(4)	-	1.57(4)	-	2.08(6)	1.30(3)	1.15(6)	1.40(3)	0.94(3)	-	1.05(3)	
Daconil® (0.25%) one spray at 50 DAS[2]	134	119	-	111	-	117	105	-	121	-	-	-	118
Daconil® (0.25%) one spray at 70 DAS	-	103	-	111	-	128	105	101	125	101	-	113	111
Sprays at 50 and 70 DAS	134	-	-	-	-	-	106	-	131	-	-	-	124
Sprays against insect pests													
Control yield (t ha^{-1})	2.25(3)	-	1.16(4)	-	1.83(3)	-	1.23(3)	1.14(6)	-	1.08(3)	-	0.79(3)	
Methylparathion (0.2%) one spray	126	-	-	-	106	-	112	113	-	153	-	111	120
Methylparathion (0.2%) two sprays	-	-	121	-	-	-	-	-	-	-	-	-	121
Insect and disease control													
Control yield (t ha^{-1})	-	2.04(4)	-	1.62(4)	-	1.73(5)	-	-	-	-	-	-	
Methylparathion 0.2% (at flowering)	-	109	-	110	-	124	-	-	-	-	-	-	115
Daconil® 0.25% (70 DAS)	-	109	-	109	-	115	-	-	-	-	-	-	111
Both sprays	-	120	-	113	-	135	-	-	-	-	-	-	123

1. Not tested.
2. DAS = Days after sowing.

obtained with application of Methylparathion spray to control foliage-feeding insects. One spray of Methylparathion at flowering combined with one spray of Daconil® at 80 days after sowing (DAS) increased groundnut pod yield by 35% in Nghe An province.

Effectiveness of combined application of promising technologies. Based on the trial results obtained in the first 2 seasons and considering the presence of different constraints in the same farmers' fields, the design of subsequent AGLOR trials was modified. In northern Vietnam modified on-farm trials were carried out during autumn 1992. The trial results indicated that split lime application in combination with Bavistin® seed treatment and *Rhizobium* inoculation was the most effective technology, giving an increase in pod yield of 29% over the control (Table 5). Addition of nitrogen fertilizer further increased yield (Table 6). During this season, the incidence

Table 5. Effect of different combinations of lime application, seed treatment, and *Rhizobium* inoculation on pod yield of groundnut in districts of northern Vietnam, autumn 1992.

Treatment	Pod yield (t ha^{-1}) Lang Giang	Dien Chau	Nghia Dan	Mean	Yield increase over control (%)
Control	1.16	0.73	1.02	0.97	
Bavistin® (1 g kg^{-1} seed) + *Rhizobium*	1.30	0.79	1.09	1.06	9
Lime (400 kg ha^{-1} basal dressing) + Bavistin® (1 g kg^{-1} seed) + *Rhizobium*	1.55	0.84	1.29	1.16	20
Lime (200 kg ha^{-1} basal + 200 kg ha^{-1} at flowering) + Bavistin® (1 g kg^{-1} seed) + *Rhizobium*	1.55	0.90	1.31	1.25	29

Table 6. Effect of diferent combinations of lime application, seed treatment, *Rhizobium* inoculation, and nitrogen fertilizer on groundnut yield in districts of northern Vietnam, autumn 1992.

Treatment	Pod yield (t ha^{-1}) Lang Giang	Dien Chau	Nghia Dan	Mean	Yield increase over control (%)
Control	1.17	0.57	1.00	0.91	
Lime (200 kg ha^{-1} at sowing and 200 kg ha^{-1} at flowering) + Bavistin® (1 g kg^{-1} seed)	1.20	0.61	1.07	0.96	6
Lime (200 kg ha^{-1} at sowing and 200 kg ha^{-1} at flowering) + Bavistin® (1 g kg^{-1} seed) + *Rhizobium*	1.22	0.68	1.30	1.08	19
Lime (200 kg ha^{-1} at sowing and 200 kg ha^{-1} at flowering) + Bavistin® (1 g kg^{-1} seed) + *Rhizobium* + Nitrogen (60 kg ha^{-1} urea)	1.57	0.66	1.24	1.16	27

of insects and diseases was rather low and there was no response to chemical sprays (Table 7).

Table 7. Effect of chemical sprays in combination with other technologies on pod yield of groundnut in districts of northern Vietnam, autumn 1992.

	Pod yield (t ha^{-1})				Yield
Treatment	Lang Giang	Dien Chau	Nghia Dan	Mean	increase over control (%)
Control	0.75	0.51	0.98	0.75	-
Rhizobium + lime (200 kg ha^{-1} at sowing and 200 kg ha^{-1} at flowering) + Bavistin® (1 g kg^{-1} seed)	1.02	0.56	1.16	0.91	21
Rhizobium + lime (200 kg ha^{-1} at sowing and 200 kg ha^{-1} at flowering) + Bavistin® (1 g kg^{-1} seed) + Daconil® (0.25% one spray)	1.03	0.64	1.06	0.91	21
Rhizobium + lime (200 kg ha^{-1} at sowing and 200 kg ha^{-1} at flowering) + Bavistin® (1 g kg^{-1} seed) + Daconil® (0.25% one spray) + Methylparathion (0.2% one spray)	1.04	0.64	1.15	0.94	26

Southern Vietnam

Following are results of on-farm trials conducted in the 1991-92 winter-spring groundnut growing season.

Number of seeds per hill. Normally the farmer sows two seeds per hill as insurance against nongermination and seedling mortality. In Duc Hoa district in Long An province, seed was treated with Captan (2 g kg'[1] seed) and sown at one seed per hill (20 x 15 cm spacing). Pod yield increased by 6% over control (farmers' practice of two seeds per hill) of 3.0 t ha^{-1}. In Trang Bang district of Tay Ninh province, sowing of selected seeds at one seed per hill (20 x 20 cm spacing) gave similar pod yield to control (2.65 t ha^{-1}). The results established that it was more economic to sow just one seed per hill, preferably with seed treatment.

Effect of superphosphate application. In a trial in Duc Hoa district of Long An province, application of 25 kg ha^{-1} phosphorus as superphosphate increased pod yield by 15% over control (2.96 t ha^{-1}). Superphosphate application also increased shelling percentage from 69% (in the control) to 75%.

Split doses of lime and nitrogen. At the same level of total application, splitting the doses of both lime and nitrogen fertilizer resulted in pod yield increases of about 10% over a complete basal application (Table 8). Hence, higher profits could be realized from reallocation of a fixed level of input.

Table 8. Effect of different methods of lime and nitrogen fertilizer application on pod yield of groundnut in districts of Tay Ninh province, southern Vietnam, winter-spring crop, 1991/92.

Treatment	Pod yield (t ha^{-1})			Yield increase over control (%)
	Duc Hoa	Cu Chi	Mean	
Lime				
Basal application (400 kg ha^{-1})	3.68	2.34	3.01	
200 kg ha^{-1} as basal + 200 kg ha^{-1} at flowering	4 10	2.62	3.36	12
Nitrogen				
100% N as basal	3.59	2.34	-	
50% N basal + 50% N as one spray at peg formation		2.62		12
50% N basal + 50% N as two sprays (at flowering and peg formation)	3.84	-	-	7

Control of foliar diseases. Among the fungicides tested, Anvil'* was found most effective in controlling foliar diseases in both summer and winter-spring seasons (Table 9).

Table 9. Effect of some fungicides applied to control foliar diseases on pod yield of groundnut in the summer crop of 1991 and the winter-spring crop of 1991/92, Phuoc Dong cooperative, Go Dau district, Tay Ninh province, southern Vietnam.

Treatment	Dose (g active ingredient ha-')	Pod yield (t ha^{-1})			* Yield increase over control (%)
		Summer 1991	Winter-Spring 1991/92	Mean	
Control (no spray)		0.93	2.07	1.50	
Daconil® (one spray, 40 DAS')	750	1.04	2.09	1.57	5
Daconil® (3 sprays, 40, 55, and 70 DAS)	750	1.07	2.38	1.73	15
Copper-Zinc (3 sprays, 40, 55, and 70 DAS)	2500	1.01	2.28	1.65	10
Anvil® (3 sprays, 40, 55, and 70 DAS)	25	1.29	2.67	1.98	32

1. DAS = days after sowing.

Farmers' Reactions and Feedback

At the project locations, farmers were willing and enthusiastic in conducting on-farm trials. The tested technologies are simple, low-input, and easily understood by farmers. The district and provincial agriculture departments have expressed their desire to extend conduct of such on-farm trials to improve the access of available technologies to farmers. Farmers consider on-farm research to be a good way of technology exchange in which interaction between scientists, extension workers, and farmers can be greatly enhanced and farmers have an opportunity to evaluate advanced technologies and select appropriate ones for themselves.

Future Research Plan to Improve Groundnut Production in Vietnam

In the coming years, combinations of promising technologies of groundnut cultivation which have been identified through the AGLOR activities will be recommended for dissemination in the major groundnut-growing areas of Vietnam. High priority will be given to breeding high-yielding varieties with a suitable maturity period and resistance to major insect pests and diseases, and implementation of integrated pest management strategies on groundnut.

Reference

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Country Reports on On-farm Research and its Role in Technology Exchange

Bangladesh

A.K.M. Altaf Hossain[1]

Introduction

Bangladesh is a small country with a population of around 114 million and with only 13.5 million hectare of arable land (Table 1). The per capita availability of land is only 0.12 ha, for a country where agriculture is a major component of its gross national product. The average size of the farm holdings of 15 million farm households is 0.91 ha. Only 5% farmers are classified as large who have more than 3 ha per capita holding and 23% of farm land. Most farmers are marginal or small. About 20% of the rural households have no cultivable land and another 25% have less than 0.2 ha. Thus agriculture production in Bangladesh has varied socioeconomic conditions with different tenurial arrangements, contractual relations, and customary rights. Under such conditions, the primary need is to achieve a sustainable farming system through on-farm research and technology exchange to increase agricultural production.

Table 1. Benchmark information on Bangladesh agriculture.

Geographical location	Latitude 20.34-26.38° N Longitude 88.01-92.42° E
No. of agroecological zones	30
Temperature	Maximum 36.6 °C (98 °F) Minimum 9.2 °C (45 °F)
Yearly rainfall	Maxium 3454 mm Minimum 1194 mm
Terrain	Floodplain 80%, Hill 12%, Terrace 8%
Total area	14.70 million ha
Arable land area	13.5 million ha
Net cropped area	8.85 million ha
Cropping intensity	160%
Total population	114 million
Population growth rate	2.17%
No. of farm household	15 million
Marginal and small household (own <1.01 ha)	10 million
Contribution of agriculture to GDP	46%
Per capita income at current factor cost (US$)	170

Source: Bangladesh Bureau of Statistics, 1988

1. Bangladesh Agricultural Research Council, Dhaka, Bangladesh.

On-farm Research

Historically agricultural research in Bangladesh has been carried out at experimental stations under ideal management conditions. Researchers usually have limited contacts with farmers and lack exposure to the actual conditions under which small farmers operate. As a result, the traditional system of research has failed to respond to the needs of the farmers. However, on-farm research in all subsectors of agriculture such as crops, livestock, fisheries, and agroforestry started in 1985 with the participation of all research institutes and universities under the National Coordinated Research Program guided by the Bangladesh Agricultural Research Council (BARC). The coordinated on-farm research program developed nearly 122 improved technologies for crops, livestock, fishery, and agroforestry production.

Mechanism of Technology Transfer

In Bangladesh, an organized nationwide technology transfer network for the crop sector started from early 1980 by merging six extension departments into the Directorate of Agriculture Extension. But the transfer of technology in such sectors as livestock, fisheries, and forestry remained isolated and unorganized. Under such a situation BARC emerged as the apex body for nine institutes (Table 2) to disseminate technology under the National Agricultural Research System (NARS) in 1985 (BARC 1991).

Table 2. List of improved technologies awaiting dissemination in Bangladesh, 1992.

	No. of technologies		
Institute	On station	On farm	Total
Bangladesh Agricultural Research Institute	58	67	125
Bangladesh Rice Research Institute	73	5	78
Bangladesh Jute Research Institute	13	18	31
Sugarcane Research and Training Institute	26	5	31
Bangladesh Forest Research Institute	16	1	17
Bangladesh Institute of Nuclear Agriculture	8		8
Bangladesh Livestock Research Institute	19	1	20
Fisheries Research Institute	4		4
Soil Resources Development Institute	5		5
Total	222	97	319

1. Not available.

The concept of technology transfer gained importance with the establishment of NARS under BARC and the creation of an unified extension service under the Directorate of Agricultural Extension. The Technology Transfer and Monitoring Unit (TTMU) at BARC provides leadership for the development and implementation of technology transfer program since late 1989. The NARS-based technology transfer program through TTMU is a new concept. It is a complex program involving many public and private sector agencies.

The TTMU keeps close contact with the NARS institute, technology transfer agencies, and nongovernment organizations (NGOs), and collects improved technologies on crops, livestock, fisheries and forestry. Each NARS institute has a delivery point from which TTMU collects those technologies. Table 2 lists the improved technologies awaiting dissemination.

There are five sectoral Technology Transfer Advisory Committees. These committees evaluate the improved transferable technology and provide guidelines for preparation of information materials for the use of such intermediary groups as extension workers at all levels, private sector dealers, NGOs, religious leaders, and school teachers, who are in direct contact with farmers. The package of information includes booklets, folders, fact sheets, slides, and video cassettes, depending on the nature of technology.

Once a technology is identified for transfer to the beneficiaries, a technology transfer team comprising scientists, subject matter specialists and communication specialists is assigned to develop technical fact sheets and other technical information packages for feeding into the technology transfer system. Thus the quality of work is ensured and the cooperation and understanding between the technology producers and users continue to improve.

Since the establishment of TTMU, 17 improved technologies for crops, forestry, and the fisheries sector have been disseminated to farmers (BARC 1989).

Technology Transfer on Food Legumes and Coarse Grains

Food legumes (or pulses) are mostly grown in the postrainy season (Nov-Apr) just after harvesting of *Aman* rice. Maize and millet are the two major coarse grains grown mostly in the rainy season (Apr-Sep). Coarse grains are generally grown on marginal land, and pulses on nonirrigated land with low inputs. The area under pulses has been shrinking continuously since the early 1960s and has declined to 0.6 million ha in 1991 from 0.9 million ha in 1981. The total production is little over 0.5 million t. The main cause for reduction of the area under pulses is due to expansion of irrigation projects. Irrigated land area has now reached 2.2 million ha which is equivalent to 20% of the country's net cultivable area. Irrigated land is mainly used by the farmers for rice culture, at the cost of the area under pulses. Moreover, absence of high-yielding varieties of pulses and poor management practices contribute to low production of pulses. This situation has aggravated the daily availability of pulses in the Bangladeshi diet. Present average daily consumption level is only 10 g per capita per day, while the requirement would be 40 g per capita per day.

In recent years the government has taken up a crop diversification program that includes pulses, along with other crops. The project is progressing satisfactorily (Chowdhury 1992).

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China

Zuo Mengxiao[1]

Introduction

Maize is the third major crop in area among the food crops, and the most important coarse grain in China. From the 1970s, area, production, and yield per unit area of maize have increased rapidly. In 1990, the maize-growing area covered 21.4 million ha and the total production was 96.8 million t. The proportion of maize to the total crop area was 18.9% and to production of national food crops was 21.7%. The average yield of maize in 1990 was 4.5 t ha^{-1}, an increase of 235% compared with that of 1952. China has three main maize production zones: the northern spring-sown maize region, the Huang Huai Hai Plain's summer-sown maize region, and the southern hills maize region.

Maize has played a major role in national grain production. Many new cultivation techniques and improved varieties were transferred to farmers by extension workers. In China, there are four levels of extension sectors: national extension center, provincial extension centers, county extension stations, and village extension stations. County and village extension stations are responsible for introducing new varieties, conducting on-farm trials, and popularizing improved cultivation technologies to farmers.

Development of Improved Cultivation Techniques

In the early 1960s, the agricultural researchers and extension workers conducted both on-station and on-farm trials so as to improve growth, development, and yield of maize. They also set up some demonstration fields to popularize research achievements in the rural areas. The following improved techniques were recommended to farmers.

- To ensure high yields of maize, nitrogen was the most important fertilizer followed by potassium and phosphorus. Production of 100 kg grains in spring-sown crop needed 3.43 kg N, 3.02 kg K, and 1.24 kg P. Compared with this, the summer-sown maize needed 2.55 kg N, 2.28 kg K, and 1.22 kg P. Fertilizer is least needed at the seedling stage, but its need increases rapidly towards the booting stage, and then decreases gradually.
- Plant density is very important in maize production as it affects the number of cobs, numbers of seeds per cob, and seed mass which are major yield components.

1. Department of Agriculture, Beijing, China.

Researchers studied the effect of plant density in relation to light intensity, soil moisture, and soil fertility and have recommended appropriate plant densities in different agroecological conditions.

- As water for irrigation is limited, much research was conducted to increase efficient use of water. According to an ancient Chinese farmers' proverb 'first little, then much', the researchers have also advocated limited irrigation at the seedling stage and adequate water supply (depending on the amount of precipitation received during the cropping season) at later crop growth stages.

To popularize advanced techniques for increasing yield many large-scale demonstrations were conducted with improved hybrid varieties, increased fertilizer input, and application of many improved cultivation techniques. The maize production program was coordinated closely between researchers and extension workers so that the research achievements and improved practices could be quickly applied to production. Many branches of research, extension, and local government departments were coordinated to resolve the problems of maize production. Farmers paid increased attention to the quality of maize which encouraged the researchers to search for the best techniques.

In the Heilongjiang province of northern China, severe frost occurs once in 3 or 4 years, following which maize yield usually decreases by about 33%. After years of on-farm research, farmers now use some of the following techniques:

- Sowing at the optimum time, with assurance of timely supply of quality seeds;
- Growing early-maturing, short-stalked, high-yielding, and disease-resistant varieties;
- Applying compound fertilizers containing nitrogen and phosphorus;
- Observing recommended plant spacing and using improved field management techniques.

After these new techniques were disseminated over the entire province, yields remained stable even in cold years, and have increased by 20% in warm years. Over the years, scientists in the Yantai Agriculture Academy have introduced several local high-yielding, open-pollinated varieties for cultivation by farmers. From 1976 onwards, several high-yielding hybrids have also been released.

Examples of On-farm Research

On-farm Trials in the Xinle County, Hebei Province

Maize yield in the Xinle County was low and unstable. In 1978, the average yield was only 3.3 t ha^{*1}. Concerned researchers undertook on-farm research and formulated several techniques for popularizing. These are:

- Regular replacement of traditional varieties with improved varieties. Since 1979, some low-yielding varieties such as Qundan-105, Bodan-1, Xiaobatang, etc., were replaced by Jinghzao-1 (an early-maturing and high-yielding variety) and Yandan-14 (a high-yielding variety).

- Increased fertilizer application to compensate for low soil fertility.
- Increased plant density from 50 000 to 65 000 plants ha^{-1}.

After these techniques were popularized, the average yield of summer-sown maize increased to 7.5 t ha^{-1}.

On-farm Trials in Shandong-Laizhou

The province of Shandong is one of China's main maize-producing regions. Large areas of summer maize are sown after winter wheat is harvested. In recent years the workers of Laizhou Maize Research Institute have conducted on-farm research whereby maize yields have increased to over 13.5 t ha-^{1}.

Based on these trials, it was concluded that a high leaf area index (around 5.5) should be maintained for a longer period in order to reach the targeted yield of 13.5 t ha^{-1}. It was found essential to use improved varieties that can produce more cobs at high-density sowing under nonlimiting nutrient and moisture conditions. Some varieties developed by the Laizhou Maize Research Institute (such as Yedan-12 and Yedan-13) were suitable for sowing at high density and yielded around 14 t ha*^{1}.

Republic of Korea

Han-Sang Lee[1]

Introduction

Management or cultural practices of legume and coarse grain crops are not as advanced as varietal development in Korea. The application of improved cultural practices for legumes and coarse grains has been difficult as these crops are grown on small farms that are scattered around mountainous areas. In recent years, however, gradual changes in cultural practices are being made, resulting in higher yields with less labor inputs.

Production Trend

The area and production of legume and coarse grain crops are shown in Table 1. The area for legumes and coarse grains has been continuously decreasing. This continuous decrease in area is mainly due to the low preference of farmers for these crops as compared with such cash crops as sesame, vegetables, and fruits. In contrast to the continuous decrease in area for legumes and coarse grains, the aggregate production has remained constant. This indicates a rise in production per unit area, which may be partly due to successful technology transfer of improved cultural practices as well as dissemination of improved seed to farmers.

Table 1. Trends in production and cultivated area of legume and coarse grain crops in the Republic of Korea.

	Legumes		Coarse grains	
Year	Area ('000 ha)	Production ('000 t)	Area ('000 ha)	Production ('000 t)
1980	244	266	53	170
1982	242	295	57	146
1984	233	296	45	148
1986	182	251	41	131
1988	198	302	35	120
1991	155	224	34	88

1. Upland Crops Division, Rural Development Administration, Suweon, Republic of Korea.

Development of Technologies

Fifteen research institutes of the Rural Development Administration (RDA) and nine provincial RDAs carried out 48 special and 1201 general research projects in 1991 which were aimed at increasing farmers' income, and alleviating their problems. The results of 57 projects, including development of new crop varieties and techniques to reduce production costs resulted in increased farmer's income. These research results may be utilized for improving the agricultural policies and programs of the Ministry of Agriculture, Forestry, and Fisheries.

Promising research results from 1249 research projects on cultural practices of legume and coarse grain crops, developed in RDA and provincial RDAs, were given to farmers via agricultural extension workers in cooperation with the Upland Crops Division of Technical Dissemination Bureau as well as the Rural Guidance Bureau of RDA.

On-farm Research

On-farm trials in Korea have been classified into two different systems: (1) transfer of new cultivars, and (2) transfer of cultural practices. Promising varieties developed in research institutes have to be tested at least once on-farm by farmers in cooperation with agricultural extension workers. The site selection is usually done by the research station which developed the varieties. The data on agronomic characteristics of new varieties are compared with those of existing varieties, and are reported to the Ministry of Agriculture, Forestry, and Fisheries for registration.

However, improved techniques for cultural practices are evaluated by the Technical Dissemination Bureau, and Rural Guidance Bureau of RDA. The technologies selected are demonstrated by agricultural extension workers in the field. Farmers decide by themselves to adopt the new techniques. Active OFR is conducted with government support. Sites for OFR are selected on the basis of farm size, level of mechanization, and motivation of the land owner. At present, nine locations for upland crops cultivation for large-scale farming have been selected to demonstrate the profitability of mechanization to farmers.

Role of Technology Transfer and its Results

In the 1960s, agricultural extension put special emphasis on rural home improvement and increased productivity. Afterwards, the green revolution in Korea was achieved through the development of Tongil' types of rice cultivars. Most technology transfer of the 1970s was aimed to disseminate cultural practices for Tongil' rice cultivation to farmers. Labor shortage, the main obstacle in agriculture during the 1980s, has led to the development of mechanization and low-cost agricultural production. The main objectives of on-farm research and technology transfer now are to reduce agricultural pollution and to prepare a regional technical plan on competitive crops to overcome trade liberalization problems. Transfers of new technologies for legume and coarse grain crops, especially for soybean and maize, are being regularly promoted.

Sowing time of soybean in Korea varies for each of the 3 different crop seasons: early to mid April for the summer crop, early to mid May for the full crop, and mid to late June for the late (after barley) crop. In the 1960s broadcasting of soybean on barley stubbles was commonly practiced in the late-crop season. However, in the 1970s row sowing by hand and in the 1980s by a four-row drill were the dominant sowing methods. By following improved management practices, the average soybean yield is now 1.5 times higher compared with that in the 1960s.

Maize is intercropped with other crops or is grown as a hedge crop around the farm to prevent lodging caused by strong winds. Relatively low maize yields were obtained in the hilly areas in the 1960s because of small-scale farming. Recently the yield has increased through introduction of a new hybrid maize cultivar 'Suweon 19' and improved cultural practices. These practices have now been adopted by farmers.

Conclusion

Agriculture in the Republic of Korea is facing new challenges. Our program of on-farm research and technology transfer has focused on: steady increases of staple food production and quality; accelerated full use of farm resources; development and utilization of high technology; improvement in rural living conditions; and training of agricultural specialists and leading farmers.

Relatively lower preference for legume and coarse grain crops has been overcome through the production of good quality seed, reduction of production costs; increased farm size; and price support. Farmers are trained in improved farming techniques by agricultural extension workers, and provided with technical services by farm management specialists.

Lao Peoples' Democratic Republic

Sisomphone Nhangnouvong[1]

Introduction

Agriculture is the mainstay of the Lao economy accounting for about two-thirds of gross domestic product. Lao agriculture is, however, still predominantly subsistence-oriented and makes little use of such inputs as improved seeds, fertilizers, and pesticides. Rice is, and will continue to be, the main crop of Laos. Other major crops are maize, groundnut, mungbean, soybean, cotton, and tobacco. Area and production of the major crops are shown in the Table 1.

The Laos Government gives importance to the role of market economy and to agriculture and forestry in the economy. It also stresses that the research system should combine the use of traditional and modern technologies to improve performance in agriculture and forestry. The Government has a clear policy to reduce shifting cultivation and replace it with more sustainable agricultural systems.

Table 1. Area, yield, and production of some major crops in Laos, 1992.

Crop	Area ('000 ha)	Yield (t ha^{-1})	Production ('000 t)
Rice	593.42	2.53	1502.36
Maize	32.14	1.83	58.60
Groundnut	14.91	0.75	11.16
Vegetables	1.67	11.0	18.36
Mungbean	3.79	0.72	2.74
Soybean	6.10	0.88	5.36
Roots and tubers	14.45	7.25	104.80
Cotton	7.16	11.24	80.49
Sugarcane	3.29	28.67	94.42
Tobacco	10.47	4.61	48.26

Source: Basic Statistics, Agriculture, and Extension Department, Ministry of Agriculture and Forestry, Laos.

1. Department of Agriculture Extension, Vientiane, Lao Peoples' Democratic Republic.

Technology Transfer for Sustainable Agriculture

The Ministry of Agriculture and Forestry (MAF) has a policy of food security and diversification of production for export markets, that aims to reduce risks and shifting cultivation, and ensure conservation of the environment. The results of research at each stage of the technology development process are analyzed and screened before planning future trials or preparing recommendations of technologies for extension. Screening requires clearly-defined criteria for performance evaluation and systematic procedures that combine multidisciplinary viewpoints and involve both research and extension. The productivity, stability, sustainability, and equitability measures of agroecosystems performance are blended into the screening criteria of technical viability, economic feasibility, and social acceptability. At different stages these criteria have different weights and trade-offs.

The technology development process in Laos is dynamic in order to be more responsive to farmers' needs. Interdisciplinary teams composed of biological, physical, and social scientists, and extension workers initiate systematic processes to determine research themes, select target agroecological zones and production system domains, diagnose farmers' constraints, and design and execute on-farm research.

The flow of technology is envisioned as being logically cyclic in nature, beginning with farmers, and ending with a better menu of choices for farmers with similar agroclimates. Emphasis is placed on the two-way flow of information between research and farmers through extension.

Technology Dissemination

Technology transfer involving the delivery of technical knowledge from international research institutes or from national research programs to technical personnel either in research or extension in the country is very limited. The nation depends very much on international relationships for appropriate methods of technology development and adaptation needed in the production, post-harvest, processing, handling, packaging, and marketing. The extension system provides farmers with technical information by means of a nonformal education process. This information allows farmers, who practice their livelihood under varying agroecological conditions, a greater range of choices to improve their income and well-being on a sustainable basis. The MAF is taking initial steps in developing systems for the provision of a larger menu of choices for farmers.

Myanmar

Maung Mar, San Myint, and Tin Hlaing[1]

Introduction

Agriculture is the mainstay of the Myanmar economy. About 76% of the 43 million population reside in rural areas. Out of a total labor force of 16 million, about 10 million (63%) are actively engaged in agriculture. Myanmar has six different agroecological zones and more than 60 crops are grown. Rice is the major crop (4.83 million ha). Oilseed crops cover about 1.99 million ha, and out of this groundnut is grown on 0.51 million ha. Food legumes cover about 0.85 million ha (Table 1).

Table 1. Area and production of major crops grown in Myanmar, 1991/92.

Crop	Area sown ('000 ha)	Yield (t ha^{-1})	Production ('000 t)	Total sown area in the country (%)
Cereals				
Rice	4832	2.84	12993	44.3
Wheat	154	0.61	90	1.4
Sorghum	140	1.27	157	1.3
Maize	35	0.28	10	0.3
Other cereals	191	0.49	87	1.7
Oilseeds				
Groundnut	510	1.46	685	4.7
Sesamum	1289	0.18	143	11.8
Sunflower	146	9.93	123	1.3
Other oilseeds	42	-'	-	0.4
Food Legumes				
Blackgram	293	0.47	123	2.7
Greengram	176	0.38	62	1.6
Butterbean	41	0.76	30	0.4
Pigeonpea	83	0.63	52	0.8
Cowpea	186	0.44	73	1.7
Chickpea	154	0.64	98	1.4
Soybean	113	0.38	40	1.0
Other legumes	79	0.45	34	0.7

1. Data not available.

Source: Myanma Agriculture Service, Yangon, Myanmar.

1. Myanma Agriculture Service, Yangon, Myanmar.

Importance of Food Legumes and Cereals

As rice is the dominant crop in Myanrnar, rice-based cropping patterns dominate the agriculture sector. Pulses or food legumes play a major role in such different cropping patterns as rice-pulses, rice-groundnut, sesame-pulses; and in mixed cropping. Such coarse grains as maize, sorghum, and millets are grown as sole crops or only in few sequential patterns, usually in the upland areas of Myanrnar.

Agricultural Research and Development

The Central Agriculture Research Institute (CARI), Yezin, and its other outreach stations are responsible for agricultural research and development. CARI is responsible for such research programs as crop improvement, crop protection, crop husbandry, and crop physiology. It also undertakes research under different agroecological regions at its outreach stations.

Appropriate technologies are further tested at the on-farm level and the proven technologies are transferred to the extension division. The feedback and constraints encountered by farmers are used to plan future research program. The relationship between the Agriculture Research Institute, Seed Division, Agriculture Extension Division, and farmers is shown in Figure 1.

Role of the Agriculture Extension Division in On-farm research

The Agriculture Extension Division and the Research Division cooperate to conduct on-farm research. Generally, the Agriculture Extension Division has staff in the villages, who have very good contact with the farmers. The recommended technologies are transferred to the Agriculture Extension Division for pilot production programs. Recently, the Agriculture Extension Division carried out the following pilot production programs:

- Integrated rural development pilot programs (at Yindaikkwin village, Taikkyi township; and Alekhin village, Kyauktaga township).
- Sesbania green manure program.
- Double-rice program.
- Rice-fish program.
- Two monsoon rice program.
- Ratooned rice program.

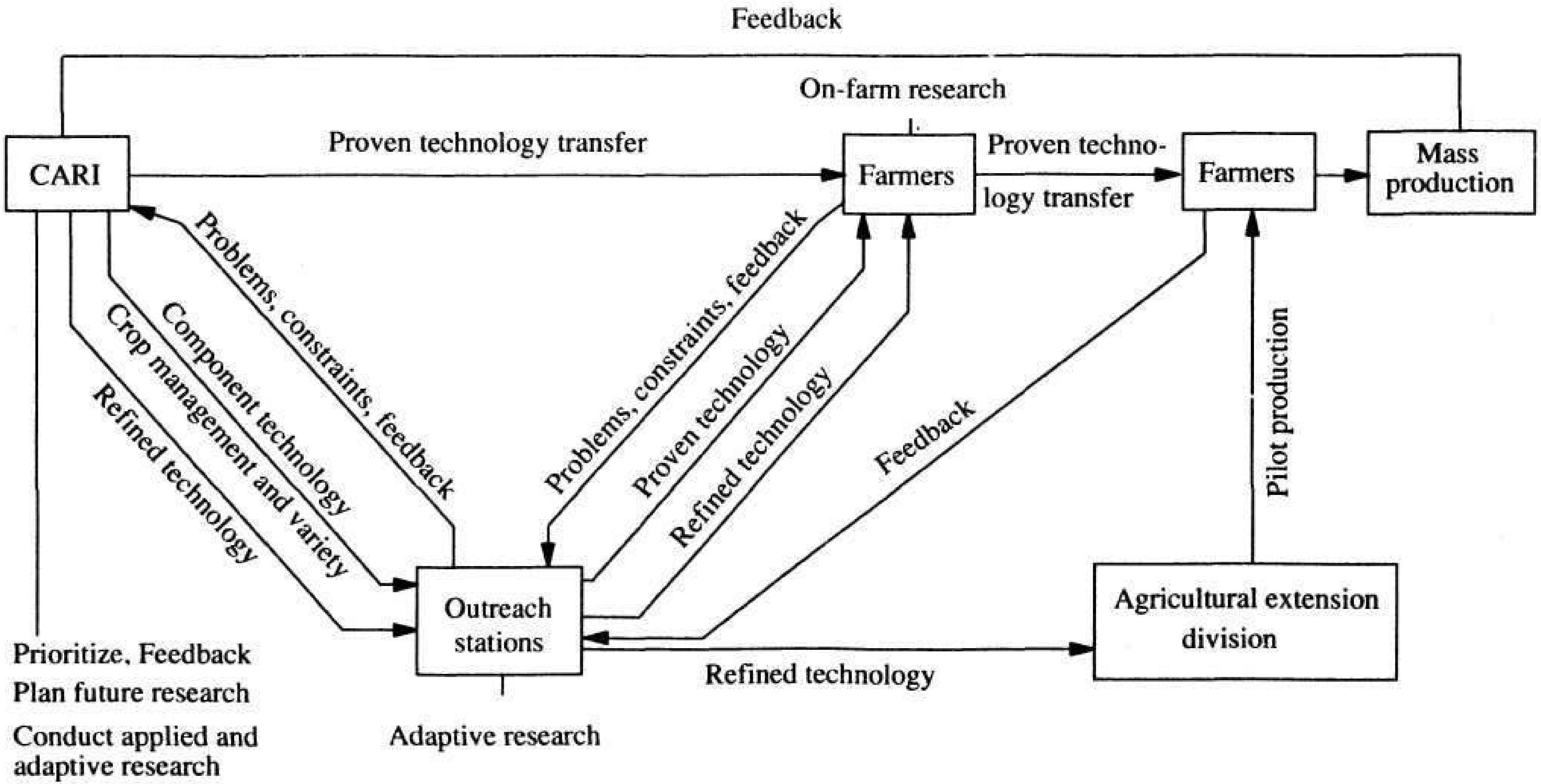

Figure 1. Linkage between the Central Agricultural Research Institute (CARI), Seed Division, Agricultural Extension Division, and farmers in Myanmar.

Impact of On-farm Research on Agricultural Development

Significant progress attained by the agriculture sector in Myanmar is as follows:

- The programs on the development of high-yielding varieties (HYVs) were started in 1960s and the HYVs now cover 50 to nearly 100% area for most of the important crops grown in Myanmar.
- The double-rice systems tested in the irrigated tracts of Myanmar and recommended by CARI are now followed in more than 0.08 million ha in 1992-93. It is planned to extend it to more than 1.62 million ha in 1993-94.
- Two monsoon rice systems were tested about 5 years ago on outreach stations and released from the research division after 2 years of on-farm research. This system was tested as pilot production in 1991-92 in two townships, and it is now planned to grow 0.27 million ha in 1993-94 under this system.
- The use of *Rhizobium* inoculum for legumes has increased substantially within this decade.
- The production of cereal crops and pulses has increased significantly within the last 5 years and consequently their export has gone up.

Pakistan

Abdur Razzaq[1]

Introduction

The rainfed *(barani)* areas of northern Punjab in Pakistan have been relatively neglected by past research efforts. Wheat is sown on over 90% of the cropped area in the postrainy season but average yields at 1.7 t ha*[1] are well below their potential. There is a need for research in the rainfed areas of Pakistan to diagnose factors that limit productivity. Past research has often not provided recommendations that are relevant to farmers of the area.

A systematic research approach is required to focus on problems in specific areas and to generate technologies that can be adopted by farmers. On-farm research (OFR) with a farming systems perspective is one possible way to achieve this (Byerlee et al. 1982). OFR is not seen as a substitute for on-station research, but as a way to test technology under actual farm conditions and provide feedback to guide on-station research.

This paper is based on research on wheat in the rainfed areas of northern Punjab from 1982 to 1988, conducted by the National Agricultural Research Center (NARC) in collaboration with the Centro internacional de mejoramiento de maiz y trigo (CIMMYT). The steps followed in the project were:

- a systematic approach to site selection;
- an initial informal survey and description of the area;
- a more focused formal survey;
- on-station agronomic research; and
- on-farm experiments.

Selection of Sites for Research

Fields were chosen on the basis of farmers' willingness to cooperate, and whether the land had been sown to maize or fallowed during the previous cycle. The latter criterion was to sample the two major cropping patterns in the area of the Punjab: wheat (rainy season)-fodder-fallow-fallow or maize-wheat-maize-wheat. Fields near villages that receive higher applications of farmyard manure (*mera* land) and those away from villages *(lepara* land) were both included in the trials.

1. National Agricultural Research Centre, Islamabad, Pakistan.

Surveys in Target Area

Surveys were conducted in the target area to interview farmers to know about their production practices and identify constraints and topics for future on-station and on-farm research. Based on the survey results, the following areas were identified for on-farm research:

- Comparison of deep tillage versus conventional tillage,
- Optimum use of balanced fertilizers,
- Evaluation of high-yielding varieties.

Results from On-farm Experiments

Tillage Experiments

Conventionally farmers in Punjab plow their field on an average of 8 times before wheat sowing. These shallow and frequent plowings keep the fields free of weeds but lead to soil compaction. This practice was compared with deep plowing using a moldboard plow. A total of 67 tillage trials were conducted in the project area from 1982 to 1987 comparing the use of a cultivator (7.5 cm deep) with that of a moldboard plow (30 cm deep). In the fallow-wheat system, primary deep plowing was done prior to the onset of the monsoon rains or just after the first rains in Jul. On fields previously sown to maize, deep plowing was done in Sep or early Oct. All plots received secondary tillage with a cultivator just before sowing.

Rainfall greatly affected the yields and the response to deep plowing in the 5 years of study. Across all sites and years, deep tillage resulted in significantly higher yields with an average yield gain of 0.88 t ha^{-1} (25%) compared with shallow tillage. There was a tendency for the relative yield difference to be greater in the dry years than years with average or good rainfall. The largest yield advantage for deep tillage was in the dry year (Table I). Yield was higher in *mera* fields than on *lepara* fields".

Table 1. Effect of tillage treatments on the grain yield of wheat in rainfed areas in northern Punjab, Pakistan, 1982-87.

Year	No. of trials	Yield (t ha^{-1}) Deep tillage	Yield (t ha^{-1}) Shallow tillage	Yield irlcrease over shallow tillage (t ha^{-1})	Yield irlcrease over shallow tillage (%)
1982/83	1	4.30 a'	3.70 b	0.60	16
1983/84	3	3.80 a	2.50 b	1.30	52
1984/85	16	2.89 a	2.13 b	0.76	36
1985/86	35	5.14 a	4.12 b	0.98	24
1986/87	12	4.11a	3.58 b	0.53	15
Mean	67	4.35 a	3.47 b	0.88	25

1. Figures followed by the same letter in the same row are not significantly different at 5% level using Duncan's Multiple Range Test

The yield gains due to deep plowing on *mera* and *lepara* land were about equal. As might be expected, the yield on fallow *lepara* land was higher than the maize-wheat system on *mera* land. Further investigations indicated that higher yields by deep plowing were due to better rooting, soil moisture conservation, looser soil profile, and reduction in weed population. Disease and pest incidence was also lower in the deep tillage treatment.

Experiments on Fertilizer

About 90% of farmers in the study area use 51 kg N and 49 kg P_2O_5 per ha, which is about 70% of the recommended dosage for the area. Ten percent of farmers do not use N, and 25% do not use P fertilizer. The on-farm trials included control (zero), and combinations of N and P (no N+P, N+no P, N+P).

Results of the trials conducted during 1983-87 indicate that:

- Wheat yield increases with application of N and P singly or in combination, but extent of increase varies across years.
- Yield increase over years was more for N than for P application.
- Interaction of N and P was not evident.
- More N is needed in wet years than in dry years, with optimum P levels remaining the same between years for the same level of yield.
- Results suggest the need for developing specific fertilizer recommendations for different land types and years, depending on rainfall.
- Use of farmyard manure increased yield significantly.

Variety Experiments

Three improved varieties (Pak 81, S 19, and Barani 83) were compared with the farmers' variety Lyallpur 73. The top performing varieties were Pak 81 and S 19, outyielding Lyallpur 73 by about 16% (Table 2). The newly released variety, Barani 83 yielded slightly more than Lyallpur 73, but significantly less than Pak 81 and S 19.

Table 2. Average grain yield (t ha[1]) of four wheat varieties in rainfed areas, 1982/83 to 1986/87.

Varieties	Years of test 1982/83 (7V	1983/84 (8)	1984/85 (13)	1985/86 (12)	1986/87 (7)	Mean 1982-87	Increase over control (%)
Pak 81	4.40 ab[2]	2.90 a	3.63 a	4.38 a	3.70 ab	3.82 a	15.7
S 19	4.60 a	2.92 a	3.58 a	4.21 ab	3.89 a	3.83 a	16.0
Barani 83	4.20 b	2.70 a	3.25 ab	3.71c	3.12b	3.41b	3.3
Lyallpur 73 (control)	3.65 c	2.59 a	2.93 b	4.11b	3.08 b	3.30 b	
Mean	4.21	2.79	3.35	4.10	3.45	3.59	

1. Figures in parenthesis denote number of locations.
2. Figures followed by same the letter in the same column are not significantly different at 5% level using Duncan's Multiple Range Test.

Conclusion

Based on the results of on-farm trials conducted during 1983-87, the scientists were able to recommend a suitable variety, tillage practice, and appropriate fertilizer application for adoption by farmers in the rainfed wheat-growing areas of Punjab.

Reference

Byerlee, D., Harrington, L., and Winkelmann, D.L. 1982. Farming system research: Issues in research strategy and technology design. American Journal of Agricultural Economics 64:897-904.

The Philippines

C.R. Escano and D.Z. Magpantay[1]

Introduction

The National Agricultural Resources Research and Development Network (NARRDN) recognizes the need for a systematic verification scheme, or on-farm trials, in farmers' field before any technology can be disseminated to the farmers. The involvement of farmers in the adaptation (fine tuning) and adoption of technologies generated in the research stations is essential in on-farm research. It is designed to compare newly developed technologies with existing farmers' practice under actual farm conditions. The on-farm trial has also been accepted by many as one of the most effective means of promoting transfer of technology from the experiment station to the farmers' field..

Development of Technologies

The NARRDN is a strategy as well as a mechanism for coordinating research and development (R and D) and promoting cooperation among institutions and agencies in the agriculture, forestry, and natural resources sectors in the Philippines.

The Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD) has established NARRDN, a network that consists of various agencies involved in R and D: research stations of the Department of Agriculture (DA), Department of Environment and Natural Resources (DENR), Department of Science and Technology (DOST), and State Colleges and Universities (SCU) located in different agroecological zones. NARRDN implements R and D projects from the point where technologies are generated/developed and disseminated. The PCARRD backstops these activities through such outreach programs as pilot production projects and communication programs.

On-farm Research Methodology

Olivia (1991) reported on-farm research (OFR) in the major maize-growing areas in Mindanao using the Centro international de mejoramiento de maiz y trigo (CIMMYT) model. The model contains the following features:

1. Philippines Council for Agriculture, Forestry, and Natural Resources Research and Development, Los Banos, The Philippines.

- First phase. Diagnose the problems through rapid rural appraisal, field surveys, secondary data, and formal interviews.
- Second phase. Plan appropriate experiments based on the identified problems, identify appropriate experimental design, and gather feedback.
- Third phase. Implement and verify technology based on technical superiority and economic feasibility using farmer-cooperators.
- Fourth phase. Assess profitability of the technology and its long-term positive effect on human ecosystem and gather feedback from the farmers or the clientele.
- Fifth phase. Disseminate the technology through demonstration farms and farmers' classes or seminars.

A diagnostic survey conducted in Carmen, Cotabato (Mindanao), during the maize-growing season found a heavy weed infestation with *Rottboellia cochinensis* (or *aguingay)* as the major problem. The soil is clay loam which is hard when dry and very sticky when wet, making land preparation difficult. There is a tendency for waterlogging during the wet season. About 80% of the area was devoted to the local variety (Tiniquib) which had an average yield of only 1.5 t ha-^{1} without fertilizer. An estimated 20% of the farmers used hybrids with high fertilizer levels (90-100 kg N ha^{1}) and obtained 4 t ha^{-1}. However, the trend towards using maize hybrids has now decreased due to their susceptibility to downy mildew.

The four priority areas identified for research during the diagnostic phase were variety, optimum fertilizer rates, weed control, and soil management appropriate for clayey, weed-infested areas.

There were three major types of trials used to address these problems. These were:

Zone-level trials or exploratory trials. Researcher-managed, small plots, replicated, full factorial trials were used to determine whether a particular input or practice (e.g., variety, fertilizer, chemical weed control) had any major effect on yield and whether it had any major interaction with other inputs or practices. These were called 'zone-level trials' because in each cycle they were sown in 4-6 different locations spread around the area.

Zone-level technology adaptation trials. Usually a small plot, replicated trial, sown at 4-6 locations around the zone was used to determine profitable levels of inputs and practices.

Zone-level multilocation testing and demonstration plot or verification trials. Large plots, unreplicated (within locations) mostly managed by farmer-cooperators and extension agents were used to determine whether results obtained in small plots could be reliable and consistently replicated over many locations.

At the same time, several suitable improved maize varieties were identified through on-station research. The OFR team instituted a program of farmer varietal screening to supplement the formal researcher-managed variety yield trails. When farmers accepted the new variety, the OFR staff organized farmer groups for seed multiplication and marketing.

The OFR project was conducted from 1987 to 1991, and from that period, considerable achievements have been attained in terms of:

Technology Utilization. From zero adoption during the first cycle (1988), about 70% of the maize farmers in the area are now sowing open-pollinated varieties (OPVs) with an average yield of 4 t ha^{-1}. Along with the improved varieties, farmers are now adopting appropriate cultural management practices such as fertilizer application, seed treatment, weed control, etc.

Expansion in cultivated area. Area cultivated for maize production increased from 200 ha in 1988 to 1200 ha in 1991 which were mostly sown to OPVs. On an average, area cultivated per farm household increased from 1.5 ha in 1988 to 4 ha in 1991.

Reference

Olivia, L.P. 1991. On-farm research terminal report 1991: On-farm research, and outreach program on corn for southern Philippines. Kabacan, Philippines: University of Southern Mindanao.

Thailand

Somyot Pichitporn[1]

Introduction

Although Thailand has long been a major exporter of rice, maize, and cassava products, Thai agriculture is still characterized by unimproved technology and consequent low yields and farm incomes in other food crops. Production increases in the past have been derived largely from expansion of the cultivated area but potential for expansion of area is now limited. Future increases in agricultural production required to supply Thailand's domestic needs, in view of the rapid rate of population growth, and to maintain its position in world export markets will have to be based on increasing the productivity of existing areas. The most direct method to achieve this goal is through the promotion of a practical approach to major problem solving, the development of simple profitable technologies acceptable to the farmer, the demonstration of the success of these technologies, and the widespread adoption of these technologies within similar ecological zones. These technologies should be tested in the farmers' fields with the participation of the farmers for their adoption.

On-farm Research Programs and Methodologies

On-farm research is an important step in agricultural research where the farmer is the primary target. It provides a basis for the relationship between researchers and farmers, linked by extension workers. Agricultural research in Thailand is mostly carried out by the Department of Agriculture (DA), universities, and agricultural colleges.

The DA is the major research organization with over 100 research centers, research stations, and experimental farms widely distributed over the major agroecological regions of the country. There are at least four universities which are involved in research to address agricultural problems in their own region. These are Kasetsart (KU) in the central province, Chaing Mai (CMU) in the northern province, Khon Kaen (KKU) in the north-eastern province, and Prince of Songkla University (PSU) in the southern province of Thailand.

The Department of Agricultural Extension (DOAE) is charged with the responsibility of conveying research results to the farmers. Extension workers need to be well trained and briefed by the research team, on the improved packages for testing and transfer.

1. Field Crops Research Institute, Bangkok, Thailand.

Both the DA and the universities conduct basic, applied, adaptive, and on-farm research. There are also many joint projects involving participation between these two organizations with the aim of increasing crop yields and utilizing resources efficiently. The Farming Systems Research Institute (FSRI), under the DA, was the link organization between research, extension, and the farmers, and was responsible for testing the results provided by research stations and universities on farm and provide feedback. The FSRI assessed the farmers' response to research-derived recommendations, and evaluate technology packages within the farming system, taking into consideration socioeconomic conditions. The FSRI has now been merged with existing technology transfer divisions in the provinces.

The Oilseed Crops Development Project was carried out with the participation of various research and extension departments and universities (Laosuwan 1993). The project aimed at increasing the production of oilseeds, including soybean, groundnut, sunflower, sesame, and castor. Investigation of basic problems for oilseed crop production, including market system, soils, fertilizers, variety development, pests, diseases, and weeds were conducted in the first 3 years. In the fourth year, however, the project objectives were directed towards adaptive research to identify production techniques and packages to be extended to farmers.

Role of Technology Transfer

The Training and Visit (T&V) methodology is the most popular approach for agricultural extension. This system depends on information recommended by disciplinary lines of research under the DA. The subject-matter specialist (SMS) derives recommended packages by consolidating disciplinary information which is then transferred to contract farmers through extension agents. However, these packages may not always be applicable as they are either too costly or not suited to field problems or the socioeconomic status of farmers in the target area.

Production constraints for oilseeds are location-specific and the choice of cultural practice depends on farmers' socioeconomic status. The steps undertaken in on-farm research techniques were: (1) identification and screening of major crop production constraints, (2) testing nesponse of different levels of treatments, (3) formulation of packages of high, medium, and low inputs and testing of these packages on farm, (4) analysis of net benefit of each package, and (5) delivery of selected packages to farmers.

Reference

Laosuwan, P. 1993. On-farm research methodology for extension: a case history from oilseeds crops in Thailand. These proceedings.

Experience from Other Organizations

CIMMYT's Contribution to the Development of On-Farm Research in Asia

L Harrington and D. Byerlee[1]

Introduction

During the late 1970s and early 1980s, a new kind of agricultural research swept much of the developing world. Known variously as farming systems research (FSR) or on-farm research (OFR), it offered the prospect of new, productive technologies for millions of farmers, particularly resource-poor farmers operating complex farming systems. The term 'on-farm research' or 'OFR' is used in this paper to refer to forms of adaptive research that feature a sensitivity to farming system interactions, a problem-solving focus, the use of skills from multiple disciplines, and suitable levels of farmer participation. Many other terms have been coined to describe research with these characteristics, among them 'farming systems research and extension', 'on-farm client-oriented research', 'farmer-back-to-farmer research', etc.

The roots of OFR may be traced partly to a 'crisis of expectations' created by the Green Revolution in Asia. The Green Revolution was enormously successful in developing new technology suitable for millions of rice and wheat farmers. This success led observers to anticipate similar achievements for other crops. Expectations were high that scores of crops, covering varied production environments would benefit from their own Green Revolutions.

In general, these expectations were not met. It became commonplace to hear of areas (e.g., hilly regions) or even whole continents (e.g., Africa) having been 'bypassed' by the Green Revolution. Some researchers felt that suitable new technologies could be developed—even for 'bypassed' farmers. These scientists, aware of the complexity of small farming systems, felt that research using a systems perspective and featuring contributions from researchers, extension workers, and farmers might greatly increase the probability of generating suitable new technology. Procedures evolved rapidly and became part of what is now known as OFR.

The development of OFR was linked to the Green Revolution in Asia in yet another way. The introduction of early-maturing, photoperiod-insensitive varieties of rice opened up opportunities for intensifying rice-based systems through the introduction of a second crop. 'Cropping systems research' gradually expanded its scope of activity to include lowland-upland interactions, crop- livestock interactions, etc., until it became indistinguishable from other kinds of OFR.

1. Centro internacional de mejoramiento de maiz y trigo, Mexico.

Numerous institutions and organizations helped foster the spread of OFR techniques in Asia, including national agricultural research systems (NARS), nongovernmental organizations (NGO), and international agricultural research centers (IARC). The objective of this paper is to describe CIMMYT's contributions to this process. First, a brief description of CIMMYT's approach to OFR is given. Then three distinct groups of collaborative OFR activities in Asia that involved CIMMYT are presented: 1} OFR on maize-based systems in Southeast Asia; 2) OFR on wheat- and maize-based systems in Pakistan; 3) collaborative research (involving OFR) on natural resource issues in the rice-wheat cropping pattern in South Asia.

CIMMYT's Approach to OFR

Over the past 2 decades, a number of approaches to OFR have been developed including cropping systems research (Zandstra et al. 1981), farmer-back-to-farmer (Rhoades and Booth 1982), farmer participatory research (Farrington and Martin 1988), and on-farm adaptive research (Byerlee 1987). CIMMYT has played a particularly important role in developing concepts and procedures associated with on-farm adaptive research.

At first glance, each of these approaches seems unique. The vocabulary and prescribed research steps appear specific to each one. There are also differences in breadth and time frame for suggested research activities. CIMMYT's approach to OFR in Asia has maintained a unique flavor that sets it somewhat apart from other approaches. Some characteristics of OFR, and CIMMYT's approach for each, include:

Systems orientation and scope of research. Virtually all OFR approaches employ a farming systems orientation, commonly achieved through intensive diagnostic studies that normally feature rapid appraisals (including farmer participatory appraisal) and formal surveys. CIMMYT fosters OFR (with a systems perspective) within commodity or disciplinary research institutions as well as specialized OFR organizations.

Interdisciplinary. A concern with farming systems necessarily implies the participation of various disciplines in research. In Asia, CIMMYT's efforts have focused on strengthening the contributions of social science and, to a lesser extent, crop agronomy in on-going OFR projects conducted by national programs.

Location-specific. OFR is usually carried out in well-defined research sites, which aim to represent a larger extrapolation area. In many OFR projects, however, these sites are too small and too few to reflect the variability in the extrapolation area. In • CIMMYT's approach, surveys and trials are conducted throughout a well-defined study area or recommendation domain, usually described in terms of important cropping patterns and agroclimatic circumstances.

Problem-solving and priority-setting. The approach taken by CIMMYT focusses on identifying problems associated with major farm enterprises, then distinguishing their causes. An understanding of causes generally helps suggest possible solutions, whether through new technology or cropping patterns, or through changes in policy. Priorities are set with regard to problems, enterprises, possible solutions, and specific research themes (Tripp and Woolley 1989).

Adaptive. OFR is often seen as a way of adapting available technologies to specific farming conditions. However, in many instances technology still needs to be developed (Tripp et al. 1990). OFR may often be more useful in guiding applied on-station research (OSR) than attempting near-term interventions (Merrill-Sands and McAllister 1988). CIMMYT's approach helps forge the OSR-OFR link by fostering OFR activities within commodity research institutions.

Overview of CIMMYT activities related to OFR in Asia

CIMMYT activities related to OFR in Asia, implemented since the late 1970s, can be divided into three main categories. (1) Some OFR focused on maize-based systems in rainfed uplands of Southeast Asia. For example, cooperative programs with the Malang Research Institute for Food Crops (MARIF) in East Java, Indonesia; the University of Southern Mindanao (USM) in the Philippines; and the Field Crops Research Institute (FCRI) of the Department of Agriculture in Thailand. (2) OFR was also featured in a USAID-funded collaborative project with the Pakistan Agricultural Research Council (PARC), on both maize- and wheat-based systems, covering three major agroclimatic regions found in the country. (3) OFR forms part of a newly-initiated NARS-CIMMYT-IRRI collaborative project to assess and improve the productivity and sustainability of rice-wheat cropping systems in four countries of South Asia (Bangladesh, India, Nepal, and Pakistan).

CIMMYT staff participating in OFR have included economists, agronomists, and plant pathologists working from CIMMYT's Asian Regional Offices in Bangkok or Kathmandu, or from the CIMMYT office in Islamabad that supported the collaboration with PARC. It should be pointed out that in all cases CIMMYT's primary contribution was to advise and counsel on OFR concepts and procedures to strengthen national program OFR efforts. In all cases, OFR featured cropping systems where one of CIMMYT's mandate crops—maize or wheat—was important.

Conclusion

Although sharing many of the fundamental characteristics of OFR, CIMMYT's collaboration with Asian NARS in activities related to OFR has maintained a unique flavor. In this collaboration, CIMMYT has provided advice and counsel to NARS' own investments in OFR.

- Although using a systems orientation, CIMMYT'S approach has focused on problems associated with specific mandate enterprises, using an understanding of system interactions to trace out the causes of these problems.
- It has aimed to avoid a breach between OFR activities and commodity and disciplinary research by fostering the use of OFR concepts and procedures within commodity research institutions as well as with specialized OFR organizations.
- It has emphasized surveys and trials throughout large but well-defined study areas or recommendation domains.
- It has emphasized the need for a strong problem focus in OFR.
- Despite a high degree of similarity in concepts and procedures, adapted in different CIMMYT-NARS projects, results and impacts varied widely. These are a tribute to the flexibility and adaptability of OFR methods.
- Some efforts led to adoption of suitable new technology by farmers, and improvements in system productivity (Indonesia, the Philippines, Pakistan). In other cases, the main output was information on ways in which policies discourage technical change (Thailand), or ways in which germplasm improvement and crop management are tightly linked (the Philippines).
- In some cases, farming systems were found to be fairly simple and crop-livestock interactions relatively unimportant (Thailand, the Philippines). In others, however, an understanding of crop-livestock interactions was found to be crucial in designing system interventions (Pakistan, marginal environments, research on soil fertility, and land degradation in rice-wheat systems).
- Similarly, in some cases, interaction between crops grown in a sequence were found to be important causes of major problems (Pakistan, favored environments; Indonesia) while in others they were not.
- Early CIMMYT collaborative OFR activities focused on near-term issues of productivity. Recently, however, there has been an increase in the emphasis given to land quality issues and system sustainability, specifically with regard to the rice-wheat cropping pattern in South Asia.

The OFR case studies summarized in this paper suggest that OFR has been a good investment in Asia. We at CIMMYT feel that our collaboration has helped make this investment even productive. We feel that Asian NARS should continue to explore ways to make OFR more useful, and we look forward to further cooperation in this venture.

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On-farm Research Methodology for Extension; a Case History from Oilseed Crops in Thailand

Paisan Laosuwan[1]

Introduction

Although Thailand has long been a major exporter of rice, maize, cassava products, mungbean, and other field crops, productivity of these crops is still low. This is due to such reasons as the poor cultural practices, unsuitable varieties, and inadequate application of production inputs. Considerable attention and finances have been given to support research and extension activities but the productivity of some of these crops has not improved substantially. Therefore, the production increases have largely come from expansion of the area of cultivated land. In order to maintain the production for domestic needs and export markets, productivity must be increased.

Present Research and Extension System in Thailand

Crop research in Thailand is mostly carried out by the Field Crops Research Institute (FCRI), universities, and regional research centers. The main portion of national financial support for field crop research is allocated to FCRI and only a small portion is provided to universities. Much of the research is planned and conducted by individual disciplinary departments at research stations to maximize yield regardless of costs. Coordination among departments or disciplines is limited to budget allocation only. The packages of practices developed from the consolidation of disciplinary recommendations are usually complex, expensive, and beyond the reach of the ordinary farmer.

In Thailand, the Department of Agricultural Extension (DOAE) is charged with the responsibility to translate and convey research results to the farmers. The extension field officers report to the Provincial Office on all administrative issues and to their headquarters in Bangkok on technical matters.

The Training and Visit methodology for agricultural extension (Benor and Harrison 1977) has been introduced and used in Thailand with certain modifications. The system is based on available information derived from research conducted in the past. However, packages developed earlier may not always be applicable as they are too costly or not suitable to field problems or to the socioeconomic status of farmers.

1. Suranaree University of Technology, Nakhon Ratchasima, Thailand.

Many types of on-farm adaptive research (e.g., farming system research approach, the farmer-participatory approach, etc.) were introduced as supplementary tools for extension to develop recommendations suitable for particular locations. The continuous flow and screening of recommendations from research agencies to farmers are required to increase farm productivity. Many of the research results must be screened on farm and modified before extending them to farmers.

Oil Crops Development Project

The Oilseed Crops Development Project (OCDP) was established as a collaboration between the Government of Thailand and the Commission of the European Communities (EC) in 1983. The Project was implemented by the Thailand Institute of Scientific and Technological Research (TISTR) with participation of agricultural research and extension organizations and universities. The objectives were to support and stimulate efforts to increase the production of available oilseed crops in Thailand including soybean, groundnut, sesame, and sunflower. This included studies on soil nutrients, varieties, pests, diseases, weeds, processing, and marketing.

After 2 years of basic research, an adaptive research approach was planned for the priority crops, and funded by the balance of EC grant. The OCDP took due note of the weakness of the existing system and developed a new concept of on-farm adaptive research in which necessary inputs are applied at economic rates. Its aim was to develop simple low-cost and low-risk technology in order to achieve high economic returns.

Groundnut Production in Southern Thailand

The major production area in southern Thailand is Phatthalung and Nakhon Si Thammarat provinces. Groundnut is grown as a sequential crop with rice or as an intercrop with young rubber trees. The total area in 1991 in southern Thailand was 7000 ha and average farmer yield was 1.3 t ha^{-1} (CAS 1991), while the total area was 121 500 ha for the country and yield was 1.37 t ha^{-1}.

At the beginning of the program in 1986/87, both on-station research to tackle basic problems and on-farm adaptive research were planned concurrently. The farming system research approach was modified to fit the objective. The procedures employed were:

Site selection and description. A multidisciplinary research team selected areas for on-farm research and identified major problems specific to the area. The research sites were limited to groundnut production areas where farmers wanted to increase yield. Exploratory survey was made to record problems associated with soils, topography, nutrient status, pests, weeds, diseases, labor, rainfall, irrigation, seeds, marketing, communication, and other socioeconomic conditions of farmers.

Input Testing. Certain inputs had to be tested on farm at many locations. Laboratory soil analysis and omission trials were conducted to identify the need for applying these inputs:

- omission trials and field trials on the effects of lime and nutrient elements such as N, P, K, Mg, Zn, B, Cu, Co, Mo, and Ni;
- effect of complete NPK fertilizer;
- effect of weed control (manual weed control, preemergence herbicide, post-emergence herbicide) ;
- effect of pest control; and
- effect of disease control.

These inputs were usually tested using such simple designs as 'with and without superimposed trials' in groundnut variety trials. However, detailed studies were employed in such cases as weed control experiment, in order to determine the most economic method.

Study on input levels. The inputs that seem to affect groundnut yield most were evaluated at different levels to measure yield increments. These inputs were lime, weed control, fungicide, and fertilizer. They were tested at four levels, i.e., no input, low, medium, and high. Other inputs, if found to affect yield, were evaluated in a similar manner.

Formulation and test of packages. Selected levels of input, which were tested in the previous stage, were combined to form the following packages of practices:

- High-input package was to estimate the maximum farm yield or potential farm yield and yield gap due to application of various production packages and systems.
- Medium-input package was aimed at future yield improvement of groundnut among farmers who already accept the low risk package. This package may be accepted by more advanced groups of farmers.
- Low-input and low-risk package was intended for subsistence farmers who are reluctant or unable to invest money.

Examples of these packages for groundnut production are shown in Table 1. These packages, treated as a single treatment, were tested in different environments. The project economist monitored all inputs and computed returns.

Table 1. Costs and returns of on-farm trials of groundnut production package at Phatthalung, southern Thailand, 1989/90.

Costs and returns	Farmers package[1]	Control package[2]	Low-input package[3]	High-input package[4]
Costs[5] (Baht ha^{-1})				
Land preparation	1 125	1 125	1 125	1 125
Own labor	7 750	-	-	-
Hired labor	.	4 250	6 350	9 650
Fertilizer	-	.	940	2 000
Herbicide (preemergence)	-	-	438	438
Fungicide	-	-	-	1 560
Insecticide	.	-	.	1 250
Lime	-	-	-	1 500
Seed	2 180	2 188	2 188	2 188
Total (Baht ha^{1})	11 063	7 563	11 041	19711
Gross net benefits				
Yield (kg ha-^{1})	2 394	1 775	3 331	4 212
Field price (Baht kg^{1})	5	5	5	5
Gross benefits (Baht ha^{-1})	11 970	8 875	16 655	21 060
Net returns (Baht ha^{1})	907	1 312	5614	1 349

1. No inputs were applied, family labor was used for hand weeding and other activities.
2. No weeding was made other than hilling up. No other inputs were applied.
3. Chemical weed control and low rates of fertilizers were applied in addition to hilling up.
4. Combination of input rates resulting from disciplinary recommendation.
5. 1 US$ = 25 Baht.

Conclusion

Recommendations of disciplinary research have to be modified and tested on farm before the are transferred to farmers. The philosophy and a case study of a new concept of on-farm adaptive research to develop crop production packages relevant to the need of small farmers are presented here. These packages were based on the consideration of risk, costs, and net benefit rather than maximum yield.

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On-farm Research in the Soybean Yield Gap Analysis Project

F. Larcon[1]

Introduction

The objective of the second phase (1988-91) of the Soybean Yield Gap Analysis Project (SYGAP II) was to identify constraints faced by soybean farmers in Indonesia and Thailand. The project proposed solutions and tested'them with selected farmers.

The project was designed along the lines of research and development methodology; making extensive use of on-farm research (OFR) as a tool for adapting the recommended technology to farmers' requirements with respect to their constraints. The adaptive research was carried out in five study sites (three in Indonesia and two in Thailand), with 40 to 50 selected farmers at each site.

The adaptation process relied on a combination of agronomic and socioeconomic research tools including experiments, testing plots, household surveys, and specific studies on the farmers' economic environment (marketing channels, prices, etc.).

The key element in the adaptation process was the testing plot where agronomic and socioeconomic approaches converged to show how far the recommended technique was compatible with farmers' constraints and resources. Therefore, through an in-depth monitoring of farmers' work on each testing plot, researchers were able to understand the technological and the socioeconomic aspects of the problem.

The combination of these research tools differed slightly in Thailand and in Indonesia. While in both countries farm monitoring was conducted during the full span of the project, experiments and testing plots were not implemented in the same order.

In Indonesia, the recommended technology was primarily adapted to local agronomic conditions through experiments and then an adapted package was proposed to farmers for testing. However, in Thailand initial test plots were established at the beginning of the project in the selected sites, and experiments were conducted later on the basis of the results of the test plots. For instance, realizing the shortage of manpower at sowing time, the project conducted several experiments to find ways to mechanize this operation.

To some extent this difference was also related to the type of cooperation developed with the farmers. Seeds, fertilizers, and pesticides were given free to the farmers in Thailand, whereas in Indonesia farmers paid for the seeds and chemicals provided by the project. Therefore, it was important in Indonesia to propose a package already adapted to the local agroecological conditions in order to enhance the attractiveness of the 'product' for which the farmer paid.

1. ESCAP CGPRT Centre, Bogor, Indonesia.

Lessons Drawn from this Experience

OFR is essentially aimed at involving farmers in the adaptation process. The Indonesian case is instructive due to the liberty given to the farmer to cooperate or not to cooperate in the adaptation process.

Farmers' Participation

The percentage of monitored farmers participating in the adaptation process increased steadily. However, the responsiveness of the farmer to the project differed between locations. The operation was highly successful in Wonogiri (upland area) where the adapted package generated a significant improvement compared with farmers' current practices. In the irrigated areas, farmers were less keen to test the proposed technology as it did not bring any noticeable solutions to their constraints.

Besides the efficiency of the proposed technology, farmers' participation in the adaptation process also depended on such logistic factors as the capacity of the project to provide inputs on time and on institutional factors. In the Karawang site, where soybean was recently introduced, the project was linked with the soybean intensification program launched by the extension department in this area during the same period.

In spite of the financial risk attached to the operation, many farmers joined the testing program. This type of relationship between researchers and farmers helped in clarifying the role of both parties in the adaptation process. Even though farmers only supported a marginal share of the operational costs, it helped to ensure their interest for the project, and made researchers more accountable to farmer cooperators for their results.

Coordination and Communications

Communication and coordination are of primary importance in OFR for collaboration among different categories of people:

Communication between economists and agronomists. OFR activities contributed greatly to the establishment of a fruitful dialogue between economists and agronomists appointed to the project. As they shared a common research object, i.e. the testing plot, they were more easily able to put into perspective both technical and economic issues, and to analyze the way in which constraints relating to one facet of the problem might have implications for others.

Communication between project staff and farmers. Good communication between project staff and farmers is one of the major factors that determines the quality of the work. Exchanges in small informal groups or big formal meetings are of primary importance. Staff were posted in each study site to achieve better contacts with farmers. Unfortunately, communication skills vary from person to person, and there is no standard procedure to be followed for accomplishing this vital task to achieve successful OFR.

Challenge of Replication and Generalization of OFR

One frequent criticism of OFR is that results are location-specific and cannot be extended and generalized to other situations. In the case of soybean, no technical breakthrough is available which may generate a spontaneous adoption by farmers. Therefore, the most feasible strategies for yield improvement rely more on adaptation of the technique to the farming system than the reverse. In this respect, OFR counts among the most efficient methods. Therefore, the question is not to what extent results can be generalized, but how can the method be more extensively used?

On-farm research is often criticized for inducing noticeable increases in operational costs. This restricts its development to some degree, in particular, in a context where financial resources of national programs are limited. In the SYGAP project, a substantial part of the budget was devoted to the monitoring of the OFR by researchers. In order to reduce the OFR operational costs, it is essential to maintain and decentralize some expertise at local level for carrying out this kind of activity. Adaptation of technology is a continuous process. On one hand, various components of the package may benefit from new research results and, on the other hand, the socio-economic background to which the technology is adapted also changes.

Dissemination of OFR method relies heavily on extension services. The services can take advantage of a wide network of offices at local level to transfer the improved technology. Hence, if a technology has to be adapted and adopted, it seems obvious that the one who transfers should also participate in the adaptation process.

Throughout the SYGAP project, researchers were very vigilant in maintaining regular contacts with the local extension services. This dialogue was set up in order to have good coordination between the various agents involved in rural development in the area, and to take advantage of extension officers' experiences. But an important motivation for this relationship was also to share the experience of scientists with extension officers.

Even though this dialogue was fruitful, it did not make the extension services interested in the OFR method. This can be explained by two factors: the objective for which this institution was designed and the difficulty of transferring a method, the success of which relies to a certain extent on personal experience.

Institutional Issues

As a heritage from the 'Green Revolution' period, extension has been designed with a top-down approach. This was needed because of the importance of the problem (food security) and the type of technique to be transferred (few local adaptations were necessary). Thus, local extension services were used to transfer, on a massive scale, a specific package without making substantial modification before its dissemination to farmers. This method has not been as efficient in the case of soybean as it was for rice. As we have seen, a technique will be much more easily adopted once it has been adapted. This process of adaptation means that some latitude has to be given to local extension officers to allow them to fine-tune the package to be disseminated and to support the development of the dialogue with farmers.

This evolution also depends on a transfer of 'know-how' from research institutions to extension services.

Formalization of 'know-how'

Training is critical for the generalization of the OFR methods. However, training methods and tools about 'know-how' are difficult to formalize.

Although literature is available on OFR, it is often oriented toward the reporting of the results of a specific experience without drawing all the lessons from it in terms of project management. There are many manuals on the specific tools that various disciplines use in OFR (experiments or survey design). But researchers are reluctant to mention difficulties and failures encountered during the project implementation, which may be instructive for other researchers involved in OFR.

But one wonders to what extent all the skills required for a successful OFR can be formalized to be systematically disseminated. As the SYGAP experience demonstrated, the success of such an approach depends largely on the capacity of communication between various categories of people, a skill which is developed only by doing. Consequently the transfer of knowledge will be more efficient if it relies on 'on-the-spot' training, where researchers and extension workers cooperate directly in the same project.

The development of this cooperation relies on reformulation of the objectives of extension services, but will also necessitate an institutionalization of more direct relations between researchers and extension services.

Because of high variation in production areas, 'BIMAS' used the results of on-farm trials by redesigning them into food production technology for each specific agroecology. For limited agroecological conditions, the recommended intensification technology is called *Inmum* (partial technology); for medium agroecological conditions, the recommended technology is called *Insus* (special intensification program with a combination of seven components); while for improved agroecological conditions, there is a special program called *Supra-insus* that consists of a combination of 10 components (Table 2).

Table 2. Various technology packages for rice production under intensification program.

Type of intensification program	Technology package	Production input factors	Extension and with farmers' cooperation
Inmum[1]	Partial	1-2	Individual farmers
Insus[2]	7-component package	5-7	Within farmers' group
Supra~insus[1]	10-component package	10	Among farmers' groups

1. Partial intensification technology recommended for limited agroecological conditions.
2. Intensification technology (seven components) recommended for medium agroecological conditions.
3. Special intensification technology (10 components) recommended for improved agroecological conditions.

The *Sapta Usaha* or 7-component technology package consists of: certified seed, efficient fertilizer application, soil preparation, improved cropping pattern, integrated pest management, proper water management, and good harvest and postharvest technology.

The *Dasa Usaha* or 10-component technology is the *Sapta Usaha* package with three additional elements i.e., plant population of more than 200 000 plants ha^{-1}, application of plant hormone or foliar fertilizer, and systematic varietal changes.

Socioeconomic aspects are also considered in the *Supra-insus* program. The program helps to bring the farmers up to date by organizing them into groups and providing all necessary help and technologies. Each farmer group covers 18-25 ha in one area. Farmers establish cooperatives in rural areas called Cooperative village units. Through such Units, farmers can get credit from the bank.

In the BIMAS program, selection of, and decisions about, cropping patterns and commodities grown in an area are based on agreement among farmers in the group or among fanner groups within the production area. Consideration is also based on the farmers' expected income. Several widespread villages in central production area are under the supervision of extension workers and called Rural extension centre areas.

From the description of a case study of Indonesia's BIMAS program, it can be concluded that:

- Despite varied socioeconomic conditions, agroecosystem differences, and farmer capabilities, farmers have improved their ability to produce above their subsistence level. This has been greatly aided by the farmers' ability to organize themselves into farmers' groups and cooperatives; to be more innovative, and to make full use of research results according to the natural resources available in their respective local areas.
- The increase of food production has been achieved through different BIMAS programs, and as a result of combined effort of research and extension. Over the years, the technology components have been combined, and the program is continually revised and refined to get the maximum effect on production, in response to specific local conditions.

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Use of On-farm Research by Agricultural Extension in Indonesia

Soelbijati Soebroto[1]

Introduction

The agricultural sector is usually characterized by low productivity and low income. This situation, to some extent, is due to low average yields of major crops compared to their yield potential. Current farmers' yields of major crops and their yield potential in research station and on-farm trials are shown in Table 1. Yield gaps exist amongst research station, on-farm trials, and farmers fields (Table 1) due to the following factors:

- low level of adoption of technology by farmers,
- low level of knowledge and skills of farmers concerning available (recommended) technologies,
- low capability of farmers to buy inputs needed for the available (recommended) technologies, and
- low levels of knowledge and skills of field extension workers for secondary crops compared with those for rice.

Table 1. Yield of major food crops in research stations and farmers' fields in Indonesia, 1980 and 1992.

Crops	Average yields (t ha^{-1})			
	Research station trials	On-farm trials	Farmers' fields 1980	Farmers' fields 1992
Lowland paddy	5.8	5.1	2.7	4.0
Secondary Crops				
Soybean	1.8	1.1	0.9	1.1
Maize	5.0-7.0	4.4	1.7	2.0
Cassava	25.0-40.0	19	11.0	12.0
Vegetable				
Shallot	10.0	8.1	5.1	5.8
Garlic	9.0	7.5	1.9	6.5
Potato	26.0	14.8	11.1	11.8

Source: Directorate of Food Crops Extension, Indonesia, 1992.

1,. Directorate of Food Crops Extension, Jakarta, Indonesia.

The flow of technologies follows a series of such activities as technology generation, adaptation, verification, and on-farm trial (sometimes demonstrations) prior to its adoption. This is a time-consuming process in which many agencies are involved in the process. The extension departments are usually involved in the on-farm trials or demonstrations to ensure that useful technologies are disseminated properly to all farmers. In Indonesia, the following terminologies are used:

On-farm Research (OFR). Research conducted by institutes to make production technology more relevant to farmers' conditions or adapted to specific agroecologies. Farmers are not involved.

On-farm Client-Oriented Research (OFCOR-ISNAR's terminology). One of the effective media for farmers to learn about improved technologies prior to their adoption.

Farming Systems Research (FSR). The terms OFCOR or OFR are sometimes interchanged with FSR, particularly in Indonesia, where OFR is considered to have a farming systems perspective.

On-farm Adaptive Research (OFAR). On-farm adaptive research is a link between the laboratory/on-station research and the actual acceptance of proven technologies by farmers, which relate to farmers of various economic strata. In most cases, the economic level of farmers determines their capacity to adopt technologies. The aim is to make sure that technology will be well adapted to specific local conditions.

Since the terminology of OFAR corresponds to OFCOR in Indonesia, this paper highlights the OFCOR program from the view of the Directorate of Food Crops Extension (DFCE), Directorate General of Food Crop Agriculture (DGFCA), Indonesia. It reviews the field experiences of DFCE involved in the ATA-395 project during 1990-92 as well as the observations made by Provincial Agricultural Services in West and Central Java where the project was located, particularly from the extension workers' points of view. The OFCOR implementation in Indonesia is closely related to loan or grant projects and the main executing agency is the Agency for Agricultural Research and Development (AARD).

Constraints of the OFCOR Program in Indonesia

Based on the observations on the OFR projects of AARD from the early seventies, and the OFCOR program particularly in the last 2 years, several issues have arisen.

- There is a need for uniform terminology which can be used by all for On-farm Adaptive Research.
- The implementation of OFCOR was limited to five provinces and to two districts per province, covering less than 5 ha per location. The results of this intensive effort have always been success stories, but whenever the program was expanded to a larger area, the success was not evident.

- Lack of political commitment from national to provincial levels has been reported as one of the main reasons for such failures.
- Since the research-extension linkages are vital, especially to identify research problem and implement the planned program both should have good understanding. Different perceptions and understanding about OFR affects the OFCOR implementation.
- Any food crop program in Indonesia needs moral and physical support from the Government at Headquarters and up to the field level. The OFCOR program sometimes creates a direct channel to the provincial level ignoring the role of Headquarters (DGFCA, DFCE), which is not desirable.
- OFCOR should liaise with the Provincial Agricultural Services (DINAS), and not with the Representative of Department of Agriculture (KANWIL). KANWIL is supposed to delegate the implementation of the OFCOR program to DINAS since KANWIL is only a coordinating agency.
- Technologies demonstrated in OFCOR were mainly concerned with agronomic aspects or production technologies and ignored the economic, political, and socio-cultural aspects. Such incomplete information creates unfavorable conditions for technology adoption by farmers.
- Technologies applied in OFCOR were based on constraints perceived by researchers rather than those perceived by farmers.
- OFCOR focused only on high-value crops which are mostly cultivated by medium-level farmers. It should concentrate on low-value crops and make them profitable for small farmers.
- The information on OFCOR trials is hardly ever interpreted in a simple (popular) form suitable for understanding by farmers.
- OFCOR was mostly implemented only in provinces where the infrastructure was well developed (Java).

To overcome these constraints, the Government launched the Decree of Agricultural Minister concerning research-extension linkage on 26 Jun 1989. This decree aims to clarify the role of different agencies with regard to research-extension activities, and avoid overlapping. The research extension decree defines the following items:

- research activities,
- agricultural activities,
- agricultural technologies,
- package of technologies,
- technology recommendation,
- agricultural information program, and
- extension material.

Three years after the establishment of the decree, each subsector has progressed well by matching activities with appropriate organization.

Based on the common failures as mentioned above, Mcintosh (1985) discussed the nature of FSR in Indonesia, and how farming system research must be integrated with other Government agencies and farmers, including the existing private enterprises, through the research and development process, as shown in Figure 1.

	Research and implementation phase					
Target area selection	1 Site description	2 Economic and biological potential	3 Design and Test	4 Pilot production program	5 Implementation	Technology transfer
Extension Local government National government	Extension Local government	Extension farmer	Extension farmer Local government Bureau of Statistics	Extension farmer Directorate of production Local government	Extension farmer National production program Local government	Extension Other national government agencies

Figure 1. A schematic representation of the research-extension workload distribution and interaction with farmers and other Government agencies in different phases of farming systems research and implementation, Indonesia.

Conclusion and Recommendation

- It is recommended that there should be a clearly designated organization for on-farm research programs involving concerned agencies and personnel from national to field levels.
- The promotion of low-value crops to become high-value crops in OFR program should be emphasized.
- The selection of OFR program should be based on actual farmers' perceived constraints rather than on researchers' identified constraints.
- The sustainability of OFR program should be backed up by additional funds from National and Provincial levels.

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Role of the Asian Development Bank in Assisting Asian Countries in Technology Exchange[1]

Dimyati Nangju[2]

Introduction

During the past quarter century, the agricultural performance in Asia has been impressive compared to other parts of the world, although there were substantial regional and country differences. The countries in the region are classified into three distinct groups based on their performance. The first group (the newly-industrialized countries or NIEs) includes Taipei (China) and Korea, whose economies expanded rapidly, resulting in a real average annual gross domestic product (GDP) growth of about 8.8% per annum during the period. The second group, including People's Republic of China and the four countries in southeast Asia (Indonesia, Malaysia, The Philippines, and Thailand), which also performed well with real average annual GDP growth of 6.5 to 7.1% (except the Philippines which recorded a somewhat lower figure). In the third group are low-income countries of South Asia, whose economies have also grown but at a much slower rate of about 4.6%.

The population of Asia is projected to increase by about 20% from 5 billion in 1990 to 6 billion in 2000. To meet the food need of this increased population, food production should grow faster than the population. An assessment of the available land resources suggests that about 75% of the extra food supply will have to come from higher crop productivity since there is very limited scope for expansion of the cultivated area. In turn, this yield improvement will require major investments in crop intensification programs together with major increases in the use of credit and farm inputs, including improved seeds, fertilizers, and chemical pesticides. Agricultural research also needs to be intensified to develop improved technologies and high-yielding varieties adapted to different soils and climatic conditions.

Despite the remarkable performance of agriculture, the Asia region still has a high incidence of poverty and malnutrition. According to a recent report, there are about 700 million people living in poverty in the Asian Development Bank's (ADB) developing member countries (DMCs) with some 420 million of them facing an extreme degree of poverty. The total figure represents more than two-thirds of the world's poor. Poverty is pervasive in South Asia, where measures to combat it have been substantially offset by large increases in populations.

1. The views expressed in this paper are those of the author and not necessarily the view of the Asian Development Bank.
2. Asian Development Bank, Manila, The Philippines.

ADB's Role in Agricultural Development

Since its establishment in 1966, the ADB has always accorded high priority to agricultural development in the Asia-Pacific Region. This is due to the fact that the agriculture sector is the most dominant sector in most Asian countries. During 1968-91, agriculture and agroindustry remained the most important sector of Bank operations, accounting for about 28% of its cumulative lending of about US$ 37.6 billion, and about 36% of its grant-financed technical assistance of about US$ 2.7 billion. Bank lending has supported the region's growth in agricultural production, rural employment, and farm incomes. In recent years, the focus of the Bank's lending has been shifting increasingly to agricultural diversification, poverty alleviation, facilitating greater participation of women in developmental efforts, and environmental protection, in line with the Bank's Medium-Term Strategic Framework.

ADB's Approach to Agricultural Research

To achieve sustainable agricultural development, the DMCs should increase agricultural productivity without destroying land and water resources. The development of agricultural technology must take into account the agroecological, socioeconomic, and political conditions in each of the countries. Such location-specific and situation-specific technology should be refined locally through on-farm research so that it can be adopted by farmers with minimum risks. There is no question that strong agricultural research programs are essential for sustaining a dynamic development program in the region.

An international system of agricultural research has evolved over the last 3 decades. At the core of this system are the national agricultural research systems (NARS). Since the 1960s, various international agricultural research centers (IARCs) and regional research institutions have been established to spearhead efforts in the agriculture sector.

The NARS in many DMCs, however, are not cohesively structured. Linkages and communications among the institutions are weak, and many additional problems and constraints impede their rapid development. Many of the problems stem from shortages of funds, manpower, facilities, and lack of appropriate research plans and strategies. The Bank's policy is to assist DMCs in reviewing their NARS, and reorienting them to meet priority needs.

The Bank follows a three-point policy in funding agricultural research. First, as a regional institution, the Bank only supports research projects in the Asia-Pacific region. Second, the Bank does not make general budget-support grants. Third, the Bank supports measurable and time-bound research projects pertinent to its operations in the agriculture sector.

The Bank places considerable emphasis on production-oriented adaptive research which will directly benefit small farmers. Project components are structured to facilitate a continuous flow of new proven technology for increasing farm output. Such projects provide for the transfer of new technology through research and extension services.

Agricultural research at the Consultative Group on International Agricultural Research (CGIAR) centers and at other IARCs in the region are an important source of technological breakthrough in many fields. The Bank therefore maintains close contact with these centers. In 1971, the Bank became a member of the CGIAR. Support for international agricultural research is channelled by the Bank to the IARCs through regional technical assistance projects (RETAs) or through national advisory technical assistance projects (AOTAs) in cases where IARC outreach support is specific to a NARS. Such support is made available on a project basis rather than as direct budgetary support. However, Bank support to CGIAR and non-CGIAR centers has been modest. A recent study shows that the amount provided annually by the Bank to CGIAR centers was about US$ 1.5-$2.0 million while the World Bank contributed US$ 35.1 million, the Inter-American Development Bank US$ 6.3 million and the African Development Bank US$ 1.5 million per year.

In 1988, the Bank carried out a comprehensive review of Bank assistance to agricultural research and extension (R&E) support. The results of the review are summarized below.

General Research and Extension Support

Over the period 1967-87, the Bank financed 216 agricultural loan projects (with R&E components totalling US$ 251.6 million), 291 technical assistance projects (with R&E components totalling US$ 43.4 million), and 82 RETAs (with R&E components totalling US$ 18.6 million). Total Bank support for R&E components of agricultural loans, Technical Assistance (TA's), and RETAs was US$ 313.6 million, which is 4.5% of the total agricultural lending. In comparison, R&E support of the Inter-American Development Bank, for example, was 6.7% of the total agricultural lending during 1969-87, while that of the World Bank was 9% of the total agricultural lending during 1970-87.

Support to Research and Extension of Specific Countries

The leading country-recipients of Bank R&E support during 1967-87 have been Indonesia, Pakistan, Bangladesh, Republic of Korea, Sri Lanka, Thailand, Malaysia, and The Philippines. These eight DMCs account for 88.6% of the total amount of R&E support provided by ADB. These amounts clearly indicate that the DMCs recognize the importance of R&E in support of their efforts to improve agricultural productivity.

Research and Extension Support by Subsectors

During the 1967-87 period, the total Bank R&E support (i.e., loans and TAs) to the agriculture sector was US$ 313.6 million, as indicated below:

- Crops, US$ 82.8 million (24.6%);
- Fisheries, US$ 60.1 million (19.2%);
- Irrigation and water resources, US$ 50.6 million (16.1%);
- Livestock, US$ 38.3 million (12.2%);
- Climate, land and resource-base research, US$ 36.8 million (11.7%);
- Socioeconomic and policy research, US$ 21.5 million (6.9%); and
- Forestry, US$ 13.8 million (4.4%).

The Bank's current strategy relating to agricultural research is summarized below:

- Agricultural research at the international level must be intensified to develop high-yielding technology for less favorable environments;
- DMCs must greatly enhance their efforts to adapt research results to local needs so that the large mass of small farmers can benefit from improved technologies;
- The Bank will continue its support to international research institutes to ensure that issues of particular concern to its DMCs are covered in their activities, and that research results are transmitted to DMCs through outreach programs;
- The Bank will continue its support for national research, particularly to strengthen adaptive research at the local level; and
- Particular attention will be paid to rainfed farming, to hitherto neglected crops, and to the integration of crop, livestock, and forestry activities.

Summary and Conclusion

Compared with other regions of the world, the agricultural performance in Asia during the past 2 decades was impressive although it varied greatly among countries in the region. With the projected population increase of one billion during the next decade and the large pockets of poverty in several countries in Asia, the future challenges would be to increase food production, improve farm income and generate employment to meet the needs of the growing population. Increasing agricultural production through improvement and intensification of agricultural research has been shown to be highly cost-effective and produces high returns. Since its establishment in 1966, the Bank has provided research support to NARS and IARCs through technical assistance grants and loans. However, compared with the World Bank and other regional development banks, ADB support to research has been modest. There is scope for the Bank to increase its support to agricultural research which can be facilitated if NARS take urgent steps to increase their capacity to undertake research and to absorb funding from ADB and other donors.

Recommendations

Participants were organized into four groups to formulate recommendations under the following topics (guided by the group leaders):

- Constraint identification and diagnosis (D.Z. Magpantay)
- Planning of experiments to alleviate constraints (Haeruddin Taslim)
- Farmer involvement in on-farm research (C.E. van Santen)
- Dissemination of technology and its assessment (Ma. Cynthia S. Bantilan)

After the group leaders presented the respective recommendations to the workshop, these were discussed by all participants and modifications were made as suggested.

Constraint Identification and Diagnosis

1. In view of the many different terminologies relating to on-farm activities, there is a need for those working together on particular on-farm exercises to clearly define the terminology they wish to use. Similarly, other working groups need to standardize the use of units of measurement.
2. Socioeconomic constraints affecting technology adoption need to be clearly identified and addressed by both government and private sectors. Issues needing particular attention include:
    - Government policies;
    - Credit availability;
    - Price stability, market availability, and transport systems;
    - Irrigation and drainage management and facilities; and
    - Timely availability of inputs.
3. More precise techniques for diagnosis are required so as to be able to readily identify causal components of often apparently complex problems identified by farmers or seen on farmers' fields. As an example, poor plant stand could be caused by several factors, such as poor seed quality, deficient or excessive soil moisture at establishment, diseases, pests, etc. There is much scope for training of on-farm adaptive research (OFAR) participants in diagnostic techniques for abiotic and biotic stresses.
4. Prioritization of constraints should be based on areas affected (spatial), frequency of incidence (temporal), and yield loss estimates. Standardized methods of yield loss estimation are needed.
5. Having estimated yield loss due to particular constraints, it is then necessary to consider economic losses and advantages to be gained from remedial measures, and how these affect farmers' response to improved technologies.
6. A preliminary assessment of constraints can be made through compilation of existing recorded data and by interview of farmers through such techniques as rapid rural appraisal (RRA).

7. Successful use of RRA involves:
   - a multidisciplinary team comprising scientists/researchers and agricultural extension/services personnel;
   - conduct of the survey at the appropriate time of the cropping season. However, follow-up surveys at other times are usually also necessary, to properly identify constraints most apparent at those times;
   - selection of representative samples of specific target groups of farmers;
   - use of sound survey techniques (e.g. cross-checking);
   - use of group interviews to address problems that need group or community action;
   - development of listening, rather than evangelizing, techniques so as to be able to establish good rapport with farmers; and
   - depending on the particular situation, considering various options for obtaining feedback from farmers, e.g., formal and informal interviews, field days, women farmers' days, etc.
8. Essential basic data that need to be collected include: soil characteristics, weather, land use, cropping pattern, farming practices, area and yields of individual crops, availability of irrigation, socioeconomic conditions and demographic profile of farmers and target area, input availability, infrastructure, transportation, communication, and marketing systems.
9. Sources to be consulted include: farmers in groups or as individuals, key farmer leaders, informal farmer leaders, extension personnel, government agencies and officials, traders and middlemen, and market outlets.
10. It should be carefully assessed as to whether particular constraints are location-specific or of widespread occurrence, so that resources to tackle them can be appropriately allocated.

Planning of Experiments to Alleviate Constraints

1. Planning and experimentation of on-farm adaptive research is the most crucial component of the process of technology generation and transfer. The success of the whole process depends on the soundness of planning and its implementation which will generate strong confidence among all participants, i.e., researchers, extension workers, and farmers. For this process to be successful, it is important that these three parties work together throughout the whole process. However, different steps of this process may require major inputs from different parties depending on the stage of development of the process.

The following table summarizes the suggested arrangements, emphasizing a bottom-up approach and close linkages between researchers, extension workers and farmers:

Activity	State of technology development		
	On-farm and backup research	Development and modification of technology	Verification and demonstration of technology
Priority setting	R,E,F[1]	E,R,F	E,R,F
Design of on-farm experiments	R	R,E,F	F,E
Implementation of experiments			
Selection of site	R,F, (+E)	E,R,F	F,E
Trial management	R,F	E,F,R	F,E
Data collection	R	R,E	E,F
Assessment of experimentation	R	R,E,F	E,F,R

1. R = Researcher (includes economists/social scientists); E = Extension staff; F = Farmer; listed in order of priority for responsibility.

2. In the design of on-farm trials, the number of treatments needs to be kept to an absolute minimum, for logistical reasons. The number of treatments will depend on the questions asked. However, interactions between the major-yield limiting factors need to be accounted for, either by factorial arrangement of treatments or amelioration of yield-limiting nontreatment factors.
3. Appropriate replication procedures need to be followed, with assessment of whether replications should be on the same field or can be in different fields.
4. As the verification and demonstration stage of the OFAR process approaches, the design should become simpler and the treatments should be fewer; at the demonstration stage there are usually only two treatments: farmers' practice and the improved package of technology.

Farmer Involvement in On-Farm Adaptive Research

1. The primary target group for OFAR is small-holder farmers. These farmers:
   - cultivate in less favorable environments (soils, climate);
   - carry a great responsibility for the welfare of their families and for the fulfillment of their social obligations;
   - face the need to match risk with their limited resources, especially of capital;
   - are keen on improving productivity of their farms; and

- are interested in trying new technologies that they consider viable, in particular in experimenting with new varieties and crops.

  However, better endowed farmers should not be excluded from any improved technology exchange process, but they will need less assistance in the adoption process.

2. Due to the dual role of farmers as clients and main informants, it is essential that they are involved in all stages of the research and development process, which includes the following steps:
   - initial diagnostic survey and priority setting, e.g., rapid rural appraisal (RRA),
   - planning,
   - experimentation,
   - assessment of experimentation,
   - formulation of recommendations,
   - diffusion of new technologies, and
   - assessment of adoption.
3. As the aim of the research and development process is to increase agricultural productivity and increase farmers' income and employment, it is essential that the direction of research is determined by the needs of the target group of farmers.

   Priorities are set according to research opportunities and potential benefits to farmers, after considering the number of farmers for whom successful technology development will be relevant and the increased value per unit achieved through the introduction of the particular recommendation.
4. Participation of farmers in on-farm trials depends on the stage of the research process and the purpose of the specific trial, as illustrated in the table in the previous section.
5. Feedback between farmers and researchers needs to be ensured during the entire research and development process. This requires researcher and farmer involvement at all levels.
6. The Workshop recognized the following types of farmer involvement in OFAR, depending on the purpose of the research activity. These include:

   Contractual participation. Researchers contract with farmers to provide land or services in order to conduct diagnostic trials or to determine optimal levels of input.

   Consultative participation. Researchers consult farmers about their problems and then develop solutions. The purpose of this is to conduct diagnostic surveys and design on-farm trials. Farmers indicate their requirements (e.g. a new short-duration variety, consumer preferences, and specific pest and disease resistance), and scientists design trials accordingly. Both are thus involved in the decision-making process and a continuous dialogue and interaction is established.

Collaborative participation. Adaptive trials for situations where a new technology is already developed and further adaptation to specific farmer's situations is required.

Collegial participation. Relevant only in highly developed farming communities such as in the Republic of Korea.

7. Farmer involvement in trial design is important during the adaptive phases of OFAR, just before farmer adoption. For example, in the design of demonstrations, farmers are best able to suggest appropriate plot size, sowing date, and similar aspects.
8. In many countries, OFAR is not yet institutionalized, but is only implemented because of availability of specific donor assistance which is usually timebound. In view of its essential contribution to agricultural development through formulation of practical recommendations aimed at increasing agricultural productivity, it is recommended that OFAR be institutionalized and given a long-term perspective.
9. A prerequisite for successful OFAR programs is that adequate national government policies related to OFAR are in place before OFAR programs are initiated. This includes cooperation between different government agencies such as agricultural research, extension, and local administrative authorities. Usually, problems at the extension-research interface need special policy attention. At present these two services are usually located in different agencies, which hampers proper interaction between the two services. An additional problem in many countries in the region is that extension staff are often assigned other labor-intensive tasks in addition to their role of demonstrating new technologies to farmers. This results in unavailability of extension field workers for participation in OFAR programs.
10. In their interactions with farmers, researchers should be aware of environmental implications and should indicate possible disadvantages of new technologies, particularly in view of long-term sustainability aspects (e.g. build-up of resistance in pest or disease organisms against specific chemical control measures).
11. It is possible to make innovations with only small inputs at little or no monetary cost; e.g. timely operations.
12. The Workshop recognizes the role of women in food legume and coarse grain production. It therefore recommends that special efforts be made to involve women farmers at all stages of OFAR and to adequately assess the consequences of innovations on different family members. For all practical purposes, when this report mentions farmers this implicitly means both female and male farmers.
13. The above conclusions and recommendations are based on consideration of all four AGLOR countries but they may be more widely applicable. However, it has to be realized that the specific needs of each country would require specific considerations.

Dissemination of Technology and its Assessment

Constraints and Solutions

Internal constraints. *A* common problem is lack of improved packages of technology suitable to farmers' specific conditions. A solution to this is to have flexible packages or a range of options for specific situations. It is necessary that appropriate feedback mechanisms are incorporated into OFAR so that farmers' needs and perceptions are continually monitored.

External constraints. *A* major problem here is lack of availability of inputs, especially of quality seeds and of capital to purchase inputs. Private sector should be involved to produce hybrid and other high-value seeds. For seeds that are difficult to produce, such as groundnut, government involvement should be strengthened to improve farmers' ability to produce their own seeds. Appropriate seed certification schemes need to be implemented to ensure seed quality. For resource-poor farmers, some form of credit support is required.

Implementation of Proposed Solutions

Linkage mechanism. Efforts should be made to:

- enhance the role of extension so as to reach the maximum number of farmers,
- involve farmers in technology adaptation, and
- institutionalize feedback of information from farmers to researchers.

Information dissemination. Efforts should be made to:

- disseminate research results through extension;
- disseminate information with respect to both success and failure experienced in the use of new technologies;
- provide options for improved packages of technology, ranging from minimal inputs or changes from normal practice to a high-input level;
- have linkages between research organizations and input suppliers (e.g. seed and fertilizer producers and traders); and
- have concerted efforts to appropriately involve mass media in the extension exercise so as to make it a 'newsworthy' event.

Support policy. Government intervention is needed to:

- develop extension skills through training,
- develop credit programs that would enable farmers to purchase inputs required for improved technologies as well as to allow farmers to take the additional risks associated with their adoption, and
- adequately support extension services.

Assessment Mechanisms

- Technical and economic assessment should be conducted at each stage of the research and development process: during research planning to assess potential benefits; during implementation to monitor required refinements in the technology package; and after the research to assess adoption and impact.
- There should be a conscious effort to identify and collect reliable information/data that will allow assessment of impact of the new technology.
- Extension services have an important role to play in data collection.
- Impact assessment should be conducted by a specific institution not involved in the dissemination process.
- Economists should be involved at all stages of the research and development process so as to provide uniformity, standardization, and integration of the various biological, physical, and socioeconomic information that is required for economic evaluation and impact assessment.

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About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the semi-arid tropics. ICRISAT's mission is to conduct research which can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is one of 18 nonprofit, research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of approximately 50 public and private sector donors; it is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the World Bank, and the United Nations Development Programme (UNDP).

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