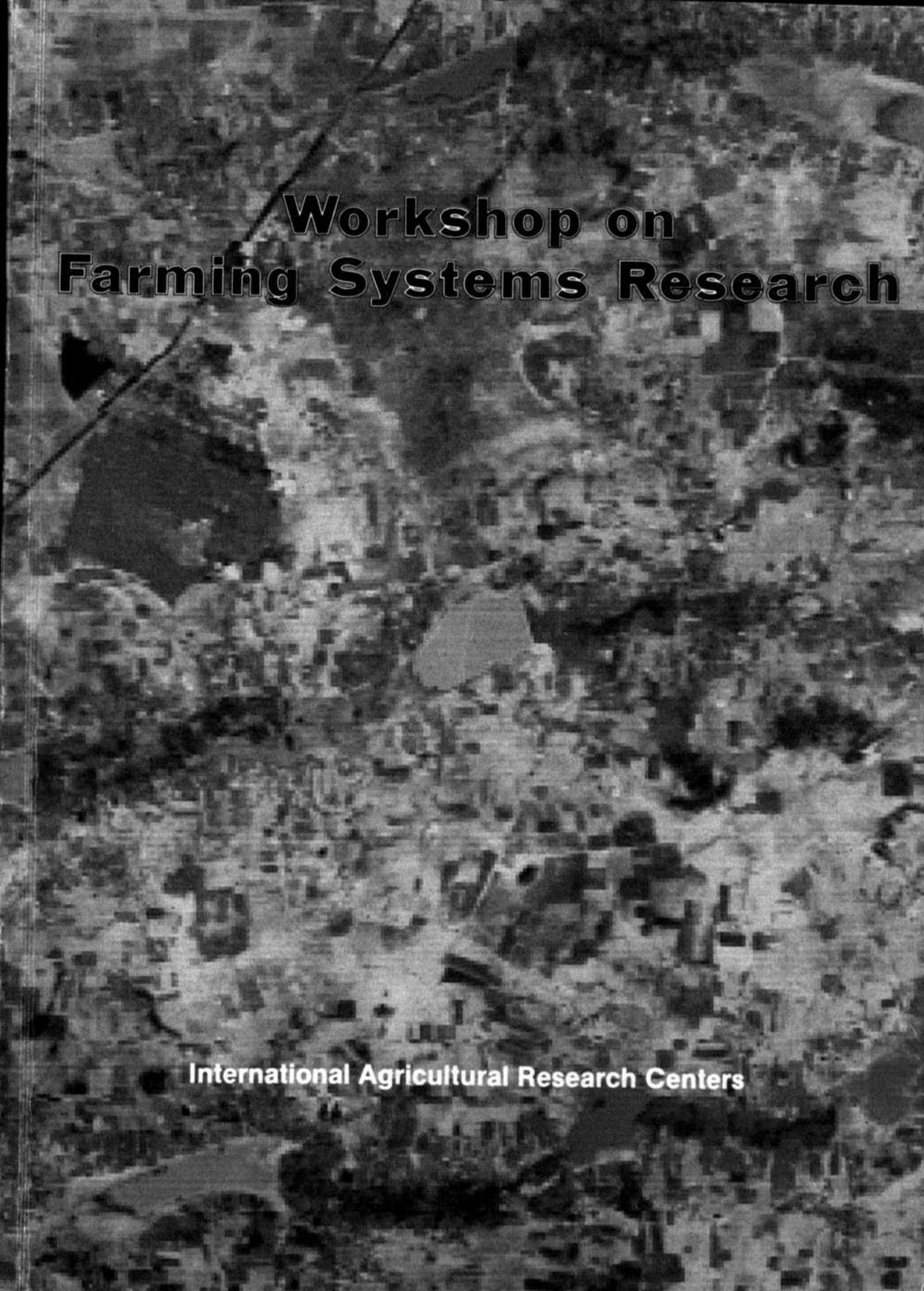

Workshop on Farming Systems Research

International Agricultural Research Centers

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International Agricultural Research Centers

Proceedings of the

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Workshop Objectives

- To develop an understanding of the relevance and approaches to Farming Systems Research (FSR) in International Agricultural Research Centers (IARCs);
- To indicate the roles of international and national research agencies in FSR;
- To harmonize the recommendations of previous reviews on FSR into an IARC framework;
- To discuss the results of case studies to assist in assessing the relevance and priority of such research for creating an impact on national systems; and
- To outline the future of FSR in the CGIAR system.

Contributed Papers

Two key papers presented at the workshop are published as full texts in these proceedings: those by Plucknett, Dillon, and Vallaeys, and Swindale. Similarly, the Reviews and Chairmen's Summaries are unamended. But other papers are published as summaries, which have been read and approved by each author or principal author. Copies of the full text of summarized papers, if required for consultation, are available from the Director, Resource Management Program, ICRISAT, or from the authors.

Acknowledgments

Vrinda Kumble, Editorial Consultant Services, New Delhi, was the publication editor, and Sarwat Hussain, ICRISAT, acted as editorial co-ordinator.

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Preface

Farming Systems Research (FSR) comprises a study of the agricultural systems of groups of farmers, and of the various factors—socioeconomic as well as technical—that influence farmers' decisions. The need for such studies is well understood; any proposed change to a farmer's system that involves more than a simple innovation requires careful consideration of the implications of such changes for the farmer, his production systems, and his society.

In recent years, the Consultative Group on International Agricultural Research (CGIAR) has provided strong leadership in FSR, through the establishment of research programs at several IARCs, and the sponsoring of reviews and workshops on the philosophy and concepts of FSR. Many other institutions outside the CGIAR system, in developing as well as developed countries, have also evinced interest in FSR. This interest has led to a widening in the views of what constitutes FSR, which in turn has created uncertainties about the definition of this area of agricultural research.

Differences in approach, subject matter, and terminology have recently become obvious where researchers from more than one IARC have initiated FSR from differing perspectives in a particular country, or have followed one another in country research programs. The Technical Advisory Committee of the CGIAR, and the Center Directors, therefore agreed that consultations should be arranged in order to harmonize the approaches to FSR within the CGIAR.

It is important that scientists, policymakers, and donors should see clearly how FSR in individual Centers fits into the generally accepted framework for FSR. In the Technical Advisory Committee we felt that such a clarification could be most efficiently achieved by convening a workshop to provide a forum for IARC scientists actively working in FSR to exchange views about the approaches they have adopted, based on their own research experience. As usual, the Centers have responded positively to a systemwide expressed need, and ICRISAT accepted the challenge to organize the workshop.

The workshop turned out to be highly successful. This success was in no small measure due to ICRISAT's initiative to associate representatives from each of the interested IARCs, from the Technical Advisory Committee, and selected eminent FSR specialists in a steering committee. This group met in New Delhi in February 1985 to draw up a framework, the guidelines for participation, and the objectives for the workshop.

I am pleased to recognize here the constructive spirit which prevailed during the discussions, as demonstrated by the useful set of recommendations that have emerged. These will provide guidance to the Centers in their future activities and will also be helpful to the Technical Advisory Committee in its decisions on matters relating to FSR at the IARCs.

Finally, I would like to thank the members of the steering committee for their advice and guidance, and ICRISAT Director General, Dr L.D. Swindale, and his staff, for making excellent arrangements for the workshop and for publishing these proceedings.

Paris
8 Oct 1986

Guy Camus
Chairman, TAC/CGIAR

Session 1

Review, Philosophy, and Concept of Farming Systems Research

Chairman: E.T. York, Jr
Rapporteurs: D. Byerlee, CIMMYT/S.M. Virmani, ICRISAT
Reviewers: N.W. Simmonds and G.T. Castillo

Review of Concepts of Farming Systems Research: the What, Why, and How

D.L. Plucknett[1], J.L. Dillon[2], and G. J. Vallaeys[3]

Introduction

During the 1977 "Stripe Review" of farming systems research at four International Agricultural Research Centers (IARCs), we found several worrying things: (1) in general, terminology being used was not very specific, nor standardized; new terms were being invented; (2) although scientists working in FSR seemed to know instinctively what they were doing and why, often they could not explain their program in any meaningful way; and (3) because of these two reasons and the newness of such research, some donors were becoming concerned about the investment in, and direction of, FSR in the IARCs. In consequence, we found it necessary to lay out a conceptual framework for FSR as an aid to existing programs as well as to provide a basis for evaluation of the work in progress at the four IARCs.

Since 1977 much has happened in FSR. The term has become common in the literature. Numerous, often very well-funded, projects and programs exist with most or a significant portion of their activities devoted to FSR. The literature is full of articles on FSR, its methods, conduct, philosophy, and expected benefits. All should be rosy in FSR.

But we see worrying signs reappearing, many of them the same concerns that were expressed in 1977. Chief among these are: a confusing array of terminology; a seeming lack of consistency in approach; the often fuzzy and seemingly all-embracing nature of many programs; the often extravagant claims for FSR; mutterings in the donor community (and elsewhere) about whether FSR is worth all the expense and effort being put into it; and—above all—just what, really, is FSR and should the IARCs be involved in it? A no less worrying question often raised is: does FSR in the IARCs or of itself provide anything useful to national agricultural research systems (NARSs) in developing countries? And—a related question—is all the talk and ferment and lack of commonality of approach just creating confusion in the NARSs?

Considerable developments have occurred since 1977 in both the legitimation and implementation of FSR. In this, IARCs have played a significant role in the development of methodology, often in partnership with national programs, and have provided strong support to NARSs in their initiation and implementation of FSR. Much important literature on FSR has been published, and more will be, as ongoing FSR studies are analyzed and documented.

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Concepts and Principles

As an approach, FSR has a strong philosophical basis; viz, that research conducted in close contact—sometimes in partnership—with the farmer can provide better understanding of farmer circumstances and help to ensure that new technology will be appropriate to farm conditions and farmer needs.

In her important paper Deborah Merrill-Sands recommended that the term FSR be replaced by the new generic term RFSP. We recognize that the term FSR has become something of a buzzword and has somewhat fallen into disrepute, but we consider that it encapsulates too important a concept to just abandon. What is important is to recognize that agricultural research for development should be geared to the needs of developing-country farmers, and that it should therefore be carried out within a farming systems perspective. This does not mean that all researchers must be FSR specialists, nor does it mean that FSR must be carried out within a special unit.

FSR scientists have done themselves and their efforts a disservice by continually coining unnecessary new terms for their work, often, it seems, not because of scientific need but because of poetic fancy or a desire for institutional trademarking. Though not unexpected in a relatively new field, FSR jargon has caused serious misunderstandings of what FSR is and does.

There is a serious need for clarification and standardization of FSR terms, and the coinage of new terms should be avoided. We hope this workshop will provide the opportunity for further progress towards agreement on FSR terminology. If complete standardization cannot be achieved, then at minimum every effort should be made to establish where equivalent terms or concepts exist.

A major misconception today is that FSR is synonymous with, and indeed limited to, on-farm research (OFR). While recognizing the importance of on-farm research, we want to correct this misconception—just as, at the other extreme, we also want to correct the misconception that FSR is an approach encompassing all aspects of agricultural development.

A Conceptual Framework for FSR

FSR should aim to meet the following interrelated objectives:

1. To understand the physical and socioeconomic environment within which agricultural production takes place.
2. To gain an understanding of the farmer in terms of his or her skills, constraints, preferences, and aspirations.
3. To comprehend and evaluate existing important farming systems, in particular, the practice and performance of these systems.
4. To improve the identification of problems and opportunities for change in existing farming systems and thereby better focus research on specific key aspects.
5. To enhance the capacity of research organizations to conduct research on priority problems.
6. To conduct research on new or improved practices or principles and to evaluate these for possible testing on farms.

7. To evaluate new or improved systems, or system components, on farms in major production areas under normal farm conditions.
8. To assist the extension, monitor the adoption, and assess the benefits of improved farming systems.

We believe that the above eight objectives of FSR can be met within the context of three interlocked multidisciplinary "activity areas"—base-data analysis, research station studies, and on-farm studies—which provide a basis for focus of research. All three activities are necessary, whether the aim be the adjustment of existing systems, their revision, or the development of new systems. We would argue that if, over time, a particular program did not involve all three of these activity areas, then it should not be seen as FSR.

Base-data analysis (BDA) involves the collection, collation, and analysis of data on the many factors characterizing the environment and farming systems of a region.

Research station studies (RSS) involve a focused research program aimed at the development of components for the improvement of existing systems or for the putting together of new systems.

On-farm studies (OFS) involve studies of existing systems, on-farm experimentation, studies of technology adoption, and assessment of the impact of new technology—all in relation to the farm household. Probably no other aspect of FSR has received as much attention in the literature as OFS.

In the Stripe Review we introduced the concepts of upstream and downstream activities as a way of emphasizing the continuum of FSR from, on the one hand, *problem identification* on the farm *and solution* of specific problems requiring component or disciplinary research on the station (upstream) to, on the other hand, the *testing and modification* of technology on the farm (downstream). We consider that the terms are apparently confusing, have been misunderstood, and should be abandoned.

Another problem we see is that FSR programs commonly describe their work via some kind of flow diagram, usually including a diagnostic stage, a design or experimental stage, a testing stage, and an extension-cum-monitoring stage. When other scientists are shown this conceptual approach, the reaction of most is: "So what is new about that? I follow that approach in most of my work all the time."

We agree that these four stages of diagnosing, designing, testing, and monitoring are important, but in truth the stages usually take place across the three activity areas of BDA, RSS, and OFS. Doing the work within that interlinked framework, and with a farming systems perspective, is what is different and distinguishes FSR from conventional commodity or disciplinary research.

Need for Farming Systems Research

There are basically two strategies to follow in agricultural research.

1. The most common and familiar one is the commodity strategy, which selects a crop or a livestock enterprise, and then moves along with the efforts required to maintain or expand production of that commodity. The parameters of the research are set by

the commodity of interest, the type of land, and other resources it employs. We are quite good at commodity work, and this is where most research resources go. The commodity approach, however, takes for granted the relevance of the commodity being researched. It largely assumes the availability of a suitable resource base in terms of land, climate, and infrastructure. In essence, it is directed to nonmarginal lands.

2. The other research strategy is resource-base oriented, and its parameters are set by what the resource base will allow. Here the resource endowment, or lack of it, determines the direction of the research, and commodity selection—either singly or in combination—is recognized as being determined by the strengths and weaknesses of the resource base. We are not as yet very good at the land capability strategy—first, because it calls for an integration of ideas from several disciplines; and, secondly, because it does not take commodity choice as predetermined but recognizes that the problem is to find a production system that can best use the available resource base either as is or as ameliorated through research. This is a broader and far more challenging research task than that taken up by the commodity approach. The resource-base strategy is the one that brings us most forcefully to dealing with marginal land situations. Obviously, the more difficult the resource base, the greater the need for a resource-base strategy in research.

FSR is needed in both strategies, but it receives its greatest challenge—and perhaps its greatest potential benefits for resource-poor producers—in the resource-base strategy. Here BDA techniques must be used more wisely and ingeniously for better characterization of the environment as well as of farmers' resources and objectives. RSS, especially those related to management of the resource base, and to design of new farming systems suited to the limitations of marginal lands, must play a major role, in combination with substantial OFS as an early and integral part of the research process. We will return to the commodity and resource-based approaches later.

We consider FSR to be very important in providing a scientific approach to problem identification and technology development aimed at improving agricultural production systems.

The goal for FSR remains the improvement of human welfare through increased but sustainable agricultural productivity.

Specific conditions presently exist that are unlikely to be adequately accommodated, if at all, by a commodity research approach of the traditional type that implies the necessity for a farming systems perspective. Among these conditions are:

- the significant increases in population, particularly in the tropical and subtropical areas of the world, which creates an immediate and ongoing need for increasing food supplies;
- the increased use of marginal lands with resource constraints that do not respond to high-yielding varieties bred for nonmarginal conditions and the threat of irreversible environmental degradation through misuse of these lands;
- the fact that most farmers in developing countries do not have the power or the means to identify and communicate their needs to research agencies and policymakers;
- the acknowledgment that there are wide gaps between results achieved in research stations and those obtainable by farmers; and

- the increasing awareness that women are major contributors to the world's food supply, particularly in developing countries, and the recognition that agricultural research has seldom considered women's roles.

In responding to these needs and deficiencies, the IARCs should not become involved in location-specific FSR unless there are strong reasons for doing so. Sufficient reasons might involve methodological or training requirements or, in some circumstances, the weakness of national programs. The IARCs do, however, have a comparative advantage and thus a case for working in the following areas or aspects of FSR.

1. Developing FSR methodology with wide application based on a holistic approach and using a multidisciplinary team.
2. Defining broad agroclimatic zones to provide basic information and feedback for plant and livestock breeders and other contributors to the design of improved farming systems.
3. Organizing workshops on FSR in the Third World. Such workshops would bring together FSR and related workers from international centers and national programs to focus on common problems and learn from each other's successes and failures.
4. Providing leadership in FSR networks. Networks are often outgrowths of workshops; they can have an important role in FSR, particularly in regions sharing broad agroclimatic features. Networks need strong leadership, particularly at an early stage, and IARC scientists are likely to provide effective guidance.
5. Printing and disseminating information on FSR. Most IARCs have high-quality printing facilities and mechanisms to keep cooperators and other researchers informed of developments.
6. Providing library resources. Most IARCs have libraries, and some provide bibliographic services and copying of material for scientists in the Third World.
7. Assisting NARSs in the institutionalization of FSR. Particularly, this lies in the capacity of ISNAR.
8. Providing training in FSR. Short courses in FSR are currently offered by IRRI, ICRISAT, IITA, and CIMMYT. More Centers could offer similar, and perhaps expanded, courses (though some degree of standardization in terminology and approach to FSR would be necessary to avoid confusion).
9. Developing new farming systems of broad potential. For some environments, particularly on marginal lands, completely new production systems may be called for. Because it will demand more basic RSS, and because its relevance may cross national boundaries, such prototype technology R&D is best conducted by international centers working in collaboration with national programs.
10. Backstopping, when necessary, for FSR workers in national programs. For countries with weak agricultural research and extension programs, this service is especially valuable.
11. Serving as a clearinghouse for FSR expertise. IARCs could compile rosters of competent specialists in FSR for their mandated commodities and regions. As necessary, teams could then be assembled to help national programs.

Current Status

Significant progress has been made in FSR; however, problem areas remain.

Two major problem areas of FSR

FSR faces two major problems, in our opinion. One, of course, is the whole range of conceptual problems. We consider that most of the conceptual framework for FSR does exist, but the understanding of that framework is, as yet, inadequate. Much more thought needs to be given to the way the conceptual framework can be applied more effectively in the conduct of FSR.

The other major area of concern is operational: how do we put the concepts of FSR into operation? FSR can be very expensive, being very demanding of both human and financial resources. Also, the number of potential areas of inquiry are very broad and encompassing, and there is always the possibility of trying to include too much in an FSR program. Problem identification and problem choice therefore become serious matters; FSR efforts should be kept to an "effective minimum," otherwise they may overwhelm a research institution, both financially and from a manpower standpoint, without a concomitant improvement in research output.

FSR methodology

During the Stripe Review in 1977, we were struck by the inadequate development of methodology for FSR, particularly for on-farm studies and base-data analysis, and, to a lesser degree, for research station studies, especially when two or more crops were grown together. Basic research designs for multidisciplinary work, statistical analyses, handling of masses of data relating to socioeconomic as well as biological and physical factors, dealing with masses of secondary data so as to sharpen knowledge about target regions or systems, all of these required much more work.

On-farm research. Our perception today—and this is largely supported by the responses we have had from the Centers—is that research methodology for OFR is much improved. Most Centers are confident that the methods being used are adequate for their purposes. ILCA is an exception, in that it considers livestock research efforts on small farms to present some daunting problems. It is probable that ICARDA would also agree with that.

We are not entirely convinced that research designs for on-farm research are adequate. Questions of number and size of plots, suitable replication, degree of involvement of researchers and farmer, and so on, may be confusing for national programs. Are there ways that the experiences of the Centers could be distilled so that the national programs could benefit?

From a survey made by Barker and Lightfoot—including responses from four IARCs of the CGIAR—it would appear that operational problems of OFR may be more limiting than conceptual problems. Operational problems mentioned included judging the correct number of replications and plot size, selection of farmers, making farmers partners in the decision-making process, "over-extension" or too ambitious a work plan, inadequate logistical support (inputs, transportation, too few resources for the area to be covered, and so on), and lack of trained manpower. Another major problem was with data analysis, particularly in projects "awash with data."

In the same survey, it would appear the major conceptual problems encountered were: whether the OFR had as its purpose technology generation (usually researcher-managed), technology verification (usually jointly managed by researcher and farmer), or technology extension (usually farmer-managed).

Base-data analysis. In our opinion, this is an area where effective methodologies are still largely lacking. Most FSR programs do not appear to make good use of secondary data in planning and targeting their research.

FSR and Strategies of Research in Agriculture

The land-capability strategy presents much greater difficulties for FSR. It requires much better use of base-data analysis of soil, climatic, ecological, and socioeconomic data, for example, than the commodity strategy. On-farm research is also more difficult, in part because the choice of target areas of farmers is much more difficult, but also because the mixes of crops or enterprises are more varied and complex. Also, by its nature, the land-capability strategy requires more effort to be expanded on new farming systems development, since few models exist that can be followed. Indeed, the land-capability strategy is usually followed in resource-limited situations, where serious problems exist for many crops. Research station studies also are more daunting because operational research methodologies for the land-resource strategy are less well developed and usually much more complex.

Part of our conceptual problems in FSR can be solved by understanding more clearly what research strategy each Center may be following. We believe there are great differences in FSR concepts and—by inference—methodologies, between the commodity and land-capability strategies.

By our definition above, CIMMYT, CIP, IRRI, and WARDA follow the commodity strategy. No Center follows a strictly resource or land-capability strategy. However, CIAT, ICARDA, IITA, ICRISAT, and ILCA follow both a commodity and a land-capability strategy; consequently they may suffer a type of "research schizophrenia," in which their commodity responsibilities can and do conflict with their land-resource (agroecological-zone) responsibilities, and—complicating their lives even more—in designing their research, they may well be mixing FSR methods best suited for one or the other of the strategies.

We are concerned about the problems a farming systems research program may have in one of the schizophrenic (from an FSR sense) Centers. How can one FSR program do an adequate job of handling the challenging, and difficult, problems of the semi-arid tropics (or the humid tropics, or the low-rainfall areas of the West Asia, or the acid savannas of Latin America) if it also has to satisfy the FSR or cropping systems research needs of the commodity programs? We suggest that the responsibilities of a Center for a land-resource mandate and for commodity mandates should be clearly defined and understood so that both areas of responsibility—as well as the methodological difficulties—can be handled satisfactorily and effectively. Perhaps some of the unrest and questioning of FSR at the dual-responsibility Centers could be alleviated if such a clear distinction as to purpose and conduct of FSR, in given situations, was made before a research program was initiated.

Conceptual Aspects of FSR

FSR has made considerable gains conceptually since 1977. A major advance has been the development and field testing of on-farm research methods and ideas. The concept that FSR work should begin and end with the farmer has been useful and, we believe, is of value to national programs in planning and executing their own FSR.

Two papers on concepts have recently been completed by N. W. Simmonds and D. Merrill-Sands. One idea that was especially useful in Simmonds' paper was the separation of new farming systems development (NFSD). We consider this to be very appropriate and helpful, in particular for the IARCs that have a major responsibility for a particular agroecological zone or where resources are limited and where NFSD will be required.

Sands listed several key concepts in FSR: "(i) FSR is farmer-oriented, (ii) FSR is systems-oriented, (iii) FSR is a problem-solving approach, (iv) FSR is interdisciplinary, (v) FSR complements mainstream commodity and disciplinary agricultural research; it does not replace it, (vi) FSR tests technology in on-farm trials, and (vii) FSR provides feedback from farmers."

We agree with these concepts and commend them as key ideas to follow in organizing and conducting FSR.

The concept of recommendation domain has been useful as a way of delimiting the level of specificity to be followed in FSR. Using base-data analysis more reliably and effectively to define recommendation domains would be an important innovation.

The concept held by some that FSR is synonymous with on-farm research is unacceptable, because it does not emphasize the two other vital areas of FSR, base-data analysis and research station studies.

We like the concept of research with a farming systems perspective (RFSP). Indeed, we consider that good agricultural research must take such an approach.

Review (1)

N.W. Simmonds[1]

It is good to have this paper from the same three authors of the TAC (1978) Stripe Review, the document that, so to speak, got FSR on the road. There is much in it with which I agree but also some points of disagreement.

First, I agree with the authors' conclusion that a farming systems perspective (FSP) is the crucial element and that very substantial progress has been made in developing this. Given FSP, FSR becomes a mode, a style or an approach to doing research and defining objectives, whether on a commodity basis or on the problems of a particular farm sector. I believe that much progress has been made and that the CIMMYT/IRRI methods of OFR/FSP have sufficiently defined the necessary practical procedures. From now on, it seems clear, FSP must and will underlie much, or perhaps all, research aimed at making local stepwise changes.

Second, I also agree with the authors in their insistence that the IARCs, having helped greatly to clarify the place of FSP, should now go wider, leave the practice of OFR/FSP to NARSs and should themselves reduce strictly locally oriented activities. Increasingly, their function must surely lie in training and in the broader, yet unexplored and more difficult, area of NFSD.

Third, I also agree with the authors in their insistence upon considering more carefully the place of women when framing research objectives; a closely related question, to which Dr Dillon referred, is of firewood gathering and the potential of agroforestry to lighten the fearsome burden often placed upon women in this connection.

However, I part company with the authors in several matters. They inveigh against Simmonds and Merrill-Sands for their terminological endeavors, yet themselves preserve the old and (dare I say it?) confused terminology, even adding some new terms; to the rubber man RSS means "rib-smoked sheet"! A coherent terminology *is* necessary and I believe that we have seen, in this meeting, the beginning of agreement on the matter; but only a beginning, alas.

Second, the authors recognize the necessity for new farming systems development (NFSD), yet hardly, it seems to me, appreciate the urgency of the need, especially in the low, wet tropics on poor soils.

Third, the authors are, I personally believe, mistaken in attributing as much importance as they do to FSR(sensu stricto). Collective experience now, it seems to me, indicates that relatively superficial analysis suffices for OFR/FSP. There may be exceptions (if some kind of NFSD were contemplated perhaps) but practicability must in general surely rule.

Fourth, and finally, the authors look to the IARCs for further technical development of the practice of OFR/FSP. I rather doubt this. It seems to me that there will still be a need for minor changes and elaborations but that, in general, the techni-

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que/methodology is plain enough, once it is recognized that the CIMMYT/IRRI approaches are effectively identical. The suggestions, raised elsewhere in the meeting, to the effect that FSR courses for NARS students could, with advantage, be staffed by teachers from more than one Center should surely help in establishing the identity; it would not only be good for the teaching but would surely contribute to understanding between Centers.

In conclusion, I welcome this useful paper and hope that the observations set out above will be useful in placing it in the general context of the meeting and of likely future developments of this important subject.

Review (2)

G.T. Castillo[1]

I would like to make 10 comments on the paper by Plucknett, Dillon, and Vallaeys.

1. Practically all the FSR experts, certainly those listed in the paper's "top 25" contributions, are from developed countries, working in developing countries. How did this come about, when the most fascinating farming systems are in the developing countries? Didn't any of us do any such type of research before FSR was invented? Certainly India must have done something along these lines a long time ago in its huge and very mature agricultural research system, but perhaps they never made such a fuss about it nor coined new words and introduced confusing terminology. This is probably a Western tradition which some of us have picked up and put to good use, especially if it helps raise money.

But our hypothesis as to why developed country researchers have become the FSR experts is because when they arrive in country X, in order to begin their work, they have to understand the existing farming system. We, the natives of the place, often assume we know the system and its problems (an assumption rarely warranted). But another colleague said that it is the reward system which has provided the motivation, and cites the example of LDC researchers who have not spent much time doing on-farm research in their own country but are doing so in another country.

Whatever the reasons are for this state of affairs, the first and most important achievement any FSR project can have is to bring the researcher in closer touch with farms and farmers in real-life settings. It is not easy to bring researchers to the field, especially after they have earned their Ph.Ds. To the extent that IARCs, donor agencies, etc., can support this process of helping the researcher get acquainted with field problems they would have made their contribution. Field exposure for LDC researchers is essential, not only in the definition of the research problem but also in the development of a heart in the right place.

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2. The key statements in the paper are as follows:

> Our belief is that any agricultural research aimed at the improvement or maintenance of productivity, whether it be commodity or resource-based... will be strongly enhanced by having a farming systems perspective.... What is important is to recognize that agricultural research for development should be geared to the needs of developing-country farmers, and that to do this it is necessary that research be carried out within a farming systems perspective because that is the context within which farmers have to operate. This does not mean that all researchers must be FSR specialists, nor does it mean that FSR must be carried out within a special FSR unit...the FSR approach should be argued as a necessary and normal part of the agricultural research process.

I concur very much with these statements, but the evangelism associated with FSR does not bother me as much as it does the authors. Perhaps if such evangelism did not exist, FSR would not have intruded as much into our thought processes. New religions serve a purpose. They help us reflect on what the "real truth" might be. Furthermore, perhaps national programs are not as confused as the paper says we are. Quite often, we practice selective perception, selective adoption, and do what we want to do anyway, despite seeming conformity to whatever model is being offered. Just like farmers, national programs probably seldom adopt the total package of innovations.

3. What bothers me more than the evangelism is the following statement: "To qualify as FSR, we believe that a program of research must (a) be conducted with a farming systems perspective, (b) involve the three activity areas of BDA, RSS, and OFS, and (c) be an integrated effort involving all scientists in the program. If any of these requirements are not met, we would not describe the research program as FSR; conversely, if all three requirements are met—as for example, is the case with CIAT's Tropical Pastures Program—we would classify the program as FSR even though, as in the case of CIAT, the term FSR is eschewed."

The danger in this statement lies in its implication that if these three requirements are not met, and a research project cannot be described as FSR, it should not be supported. And then to mention by example that certain IARC programs meet these requirements makes it even more dangerous.

It would seem that the criterion for judging whether a research program embodies the philosophy or spirit of inquiry and research perspective called for should be the extent to which it contributes to the attainment of the objectives enunciated in the paper. Suppose the paper writers were from CIMMYT, CIP, or ICARDA, would the example of "qualified" FSR research be different?

4. On the role of IARCs vis-a-vis the national programs, the paper says that IARCs "should not become involved in location-specific FSR unless there are strong reasons for doing so." One strong reason for doing so, especially in the beginning, is to acquire credibility in the eyes of the national programs.

The paper suggests that IARCs have a comparative advantage and a prima facie case for working in "developing FSR methodology with wide application based on a holistic approach and using a multidisciplinary team."

This seems rather contradictory to the spirit of FSR. It is just like developing a rice variety that will fit all seasons and meet all reasons. The IARCs can do much better than that. For example, if we take the eight interrelated objectives in the conceptual framework for FSR, the IARCs and national programs can take these objectives one by one and come up with an array of research techniques, case studies, and mechanisms for meeting each of these objectives, based on the wealth of experience that is now available. Focusing on the methodology per se can lead to methodology development as an end in itself. Furthermore, it makes people feel that there is only one way to reach the goal.

5. I hope that in asking for "some degree of standardization in terminology and approach to FSR" in order to avoid the "promulgation of confusion," the authors do not accomplish a homogenization that would stifle the creative diversity that the CGIAR system has fostered so far. The important constants in FSR are the objectives, the philosophy, and the spirit, but the ways of getting there must be a plurality, rather than a unity, of methodology.

6. This paper is indeed excellent in its views of FSR. It even mentions "including women's roles in agriculture in order to develop a more accurate picture of farming systems."

7. If we truly believe in the need for a farming systems perspective, then the concept must be introduced as early as undergraduate training; hence we miss the boat if we fail to include some universities in this FSR undertaking.

8. In defining a role for the IARCs vis-a-vis the national programs as far as FSR is concerned, we must apply the same FSR philosophy. That is, we must consider the existing national research systems, their resource base, productive capacities, etc., in designing what FSR activities are feasible and doable given their conditions.

But most of all, let us not regard them as passive receivers of intellectual light from above, because, like farmers, they must be active participants and contributors to the development of FSR. The national programs must not be perceived only as implementers of IARC methodologies. Incidentally, one of the least understood and most mysterious aspects of the IARCs' existence is how they actually relate to national programs. As a matter of fact, it has never been clear to me what exactly is being referred to when they say "national program." This is one facet which intrigues me very much. What do we mean by such an expression as "in partnership with national programs"? Where does the partnership lie? Who collaborates with whom?

9. Another vague element in these FSR concepts and principles is the role of the farmer.

a. The paper, for example, says that "as an approach, FSR has a strong philosophical basis; viz, that research conducted in close contact—*sometimes in partnership—with the farmer* ..."

b. In another part, the paper says, "the most obvious element introduced by following a FSR perspective in OFS with its *direct farmer involvement* ..."

Sometimes OFR means using the farmer's land without his getting involved. Is this OFR or is this simply on-site research undertaken by an IARC?

10. Finally, a farming systems perspective in identifying and defining problems within a commodity focus such as maize, potato, rice, or wheat is probably relatively simple. Here it is the farming systems perspective of the specific IARC focusing on its own crop which determines the parameters. But what about the *farmers' farming systems* when they are involved in several commodities which cut across Centers' mandates? Do they need to have a new farming systems perspective in the light of changing physical, biological, and human resource endowments? Which Center will be responsible for these types of situations which abound in the developing world? As a matter of fact, that *is* the real world. Some of you will probably say: "That is location-specific. That belongs to the national program."

Chairman's Summary

E.T. York, Jr[1]

The opening session was devoted to a presentation and discussion of the workshop's keynote paper by Plucknett, Dillon, and Vallaeys. The paper constituted, in effect, an updating of the report of the comprehensive Stripe Review on Farming Systems by the authors issued in 1978.

The authors are to be commended for the thorough and perceptive treatment of the subject. The paper unquestionably served its intended purposes of identifying and considering key issues and concepts as a basis for stimulating discussion during the course of the workshop.

There was, indeed, a lively discussion of the paper, with the expression of many concurring and dissenting views to those set forth in the paper. Let me refer to some of the key issues.

The authors reaffirmed their earlier position that FSR should be considered an approach to research—not a new science or discipline. Most of the workshop participants seem to be supportive of this concept and I believe it should be strongly emphasized in the workshop proceedings.

The authors recognized the imprecise and ambiguous manner in which the term FSR has been used and the confusion resulting thereupon.

The paper emphasized the need for a clarification and standardization of FSR terms and suggested that "willy-nilly'' coinage of new terms be avoided. The authors continued to advocate the terms, to classify FSR-related "activity areas", which had been used in the Stripe Review.

There was general accord among the workshop participants that clarification of terms was needed, but some felt that it would be more desirable to focus on major areas of program emphasis or thrusts rather than on where the research is centered (i.e., on- or off-station). Actually, the classification used in the paper is a combination of the two approaches. Some slight modification of this classification scheme seems desirable—perhaps more along the lines proposed by Simmonds.

The authors correctly emphasized that "FSR" and "On-farm Research" should not be considered as synonymous terms and urged that such misuse of the terms be discontinued.

In keeping with the concept of farming systems as an approach or a method for conducting research rather than a science, the authors very appropriately stressed that all researchers should not be considered farming systems specialists and that FSR should not be carried out within a special FSR unit. In this regard, I would underscore one key point made by the authors, which I consider very basic: "The FSR approach should be argued as a necessary and normal part of the agricultural research process."

The authors proposed one departure from their Stripe Review paper by advocating

1. University of Florida, Gainesville, FL, USA.

the abandonment of the "upstream-downstream" terminology in relation to FSR. This suggestion was well received by the participants.

The keynote paper suggested two strategies to follow in agricultural research—one commodity-based and the other resource-based. The ensuing discussion reflected considerable uncertainty with respect to how or why such a strategy might be applied. The ultimate goal of our efforts is to produce sustainable levels of commodities-recognizing that the nature of the resource base will affect greatly the choice of those commodities to be produced in given locations as well as the management practices to be applied. At some point the two strategies must come together. My personal opinion would be to focus on commodities, recognizing that the nature of the resource base will influence what commodities can be grown and how they should be managed.

This is not to say, however, that there would not be resource base-related basic and strategic research conducted that would be independent of commodity considerations. This is a method which, I believe, warrants further discussion.

The authors seemed to be a bit ambivalent in their treatment of what this farming systems enterprise might be called. In one part of the paper, the authors voiced some reluctance to give up the old term, FSR, while in another instance they appeared to be supportive of using the term "research with a farming system perspective" to characterize activities primarily included under the FSR label. There seemed to be general support among the participants for the use of the latter term. I believe the adoption and use of such a term would be very desirable and is consistent with the position already taken by TAC.

One issue which, in my opinion, was not adequately addressed in the keynote paper or in the subsequent discussion is whether there should be a distinction between on-farm trials to evaluate genotype * environment interactions and the type of on-farm/farmer-related research we talked about under the rubric of FSR in the workshop. One speaker pointed to the fact that genetic material on-station performed in a markedly different way from the way it does on-farm, and used that as a basis for advocating an FSR approach. We all recognize such differential behavior. However, is it not the breeders' responsibility to try to test his material under a wide range of environmental conditions to determine broad areas of adoptability? Some of this obviously can and should be done on farms. However, isn't this a different type of activity from what we are treating as FSR? I believe some further clarification of this point is needed.

While agreeing with much of the paper, let me express mild disappointment with one aspect of the paper and, indeed, with the treatment of this issue throughout the week. Very little attention has been given to the role of extension in this enterprise we call FSR. To be most successful and productive, I think there must be heavy involvement of extension in FSR activities—helping to shape the research activities, monitoring the work, and extending the results to the broader farmer community. In my opinion, one reason FSR has generated so much interest is that in many developing countries—especially Africa—extension programs are very weak or essentially nonexistent. FSR has, in part, filled a void.

The presence of strong, effective extension programs, especially those having good subject-matter specialists, closely linked to research, would serve many of the functions now being addressed in FSR—by keeping researchers constantly abreast of farmers' problems and needs and helping the researcher evaluate the acceptability to farmers of the technological products of their research.

As developing-country extension services improve, I foresee a changing role for researchers in on-farm research endeavors. This should be reflected in the IARCs' work on methodology and training.

There are many other important issues discussed in the keynote paper—all of which have contributed greatly to setting the stage for a most productive workshop.

The report of the Stripe Review made a tremendous contribution to our knowledge and understanding of FSR in the earlier stage of its development. As Dr Simmonds put it, "It got FSR on the road." The current paper, I believe, will help to keep FSR on the right road as it guides us to a more rational, meaningful, and productive approach to the application of this useful concept.

Session 2

Area-based Farming Systems Research

Chairman: N.W. Simmonds
Rapporteurs: R.A. Morris, IRRI/J.R. Burford, ICRISAT
Reviewer: N. Hudson

Farming Systems Research Relevant to the Humid Tropics, with Special Reference to Tropical Africa

R. Lal, A.S.R. Juo, and M. Ashraf[1]

Over the last two decades, remarkable progress in agricultural production has occurred where there are strong national research services and infrastructure. In the humid tropics, particularly in Africa, lack of these essentials has prevented farming methods from keeping pace with modern technology and production potential.

Simultaneously, the traditional land-extensive farming systems have been placed under tremendous pressure by a growing population that, in sub-Saharan Africa, is expected to quadruple in 44 years.

The IARCs have a small but key role to play in developing a strategy to tackle crucial issues in farming systems research in these areas. This paper describes the approach adopted by the International Institute of Tropical Agriculture (IITA) in developing viable alternatives to the traditional bush fallow systems of tropical sub-Saharan Africa.

Background

Climate and soils

Three climatic zones—subhumid, humid, and perhumid—can be distinguished, based on precipitation and evapotranspiration. Soils in the humid tropics may be generally grouped into (1) highly weathered, with low-activity clays, (2) moderately weathered, derived from basic rock and volcanic material, (3) hydromorphic or alluvial soils. The first group predominates in the humid and perhumid regions of Africa (as well as Asia and Latin America) where root cropping and "slash-and-burn" agriculture prevail.

Human resources

Sub-Saharan Africa encompasses 39 countries, containing some 800 different ethnic and linguistic groups and a total population of over 400 million. Communal land tenure prevails over most of the continent and traditional inheritance laws fragment individual holdings.

Despite the large proportion of the work force in agriculture, labor is a scarce resource, constituting 80-90% of production costs for smallholders. Migration away from rural areas further compounds this scarcity, and farm size is often limited to an area that can be managed wholly by the farm family.

In many African countries, the farm labor force consists almost entirely of women and children; yet women farmers have limited access to credit, fertilizer, extension services, etc. These facts have important implications for new technology design.

1. International Institute of Tropical Agriculture, Ibadan, Nigeria.

Traditional production systems

In the humid regions of tropical Africa, farming systems are based chiefly on root crops—cassava, yams—and plantain, grown in rotation with bush fallow. Though such systems require few purchased inputs, they are becoming increasingly inefficient, as fallow periods—formerly 7-15 years—are becoming shorter because of population pressure on land. Mixed cropping is the rule, and organic farming, using mulch and household wastes, is practiced around homesteads.

Farming Systems Research: Issues and Strategies

The majority of farmers in Africa and Asia are smallholders, who lack the education and resources to use the benefits of modern agricultural technology. Therefore, research priority must be given to the production constraints of the smallholder farmer.

Two broad options are available for raising the productivity of small farms: (1) an evolutionary step-by-step improvement leading to an improved farming system or (2) a revolutionary replacement of the entire system by a new system. The most appropriate option will be determined by the prevailing conditions—soils, climate, and human factors: the economic situation, logistic support, and rural infrastructure.

Humid tropical regions are at present characterized by nutrient-deficient soils and lack of essential inputs, credit facilities, and access to commercial markets. It is vital, therefore, to develop resource-efficient technologies. These include pest- and disease-resistant varieties that can maintain economic yields under low fertility; soil management systems that will reduce agrochemical use—e.g., mulch farming, mixed cropping; integration of livestock and woody perennials with food crops; etc. Throughout Africa, traditional farming methods require more land per capita than in Asia. Eleven counries in central Africa still have extensive areas of underused land; migration to these countries from land-scarce countries, such as Nigeria, Rwanda, and Uganda, will require entirely different new farming technologies, new seed, fertilizer, and pricing policies that support and enhance production.

Crops

Research for tropical Africa should focus on subsistence (rather than commercial or plantation) crops: cassava, yam, plantain, and cowpea. Rice is also gaining in importance and is in demand in urban areas, and maize is often grown in association with cassava.

Collaboration between IARCs and NARSs

Methodology for on-farm research should be developed, and testing and validation of improved technologies done through networks linking the IARCs with national systems. Active training programs should help expand national agricultural manpower capability.

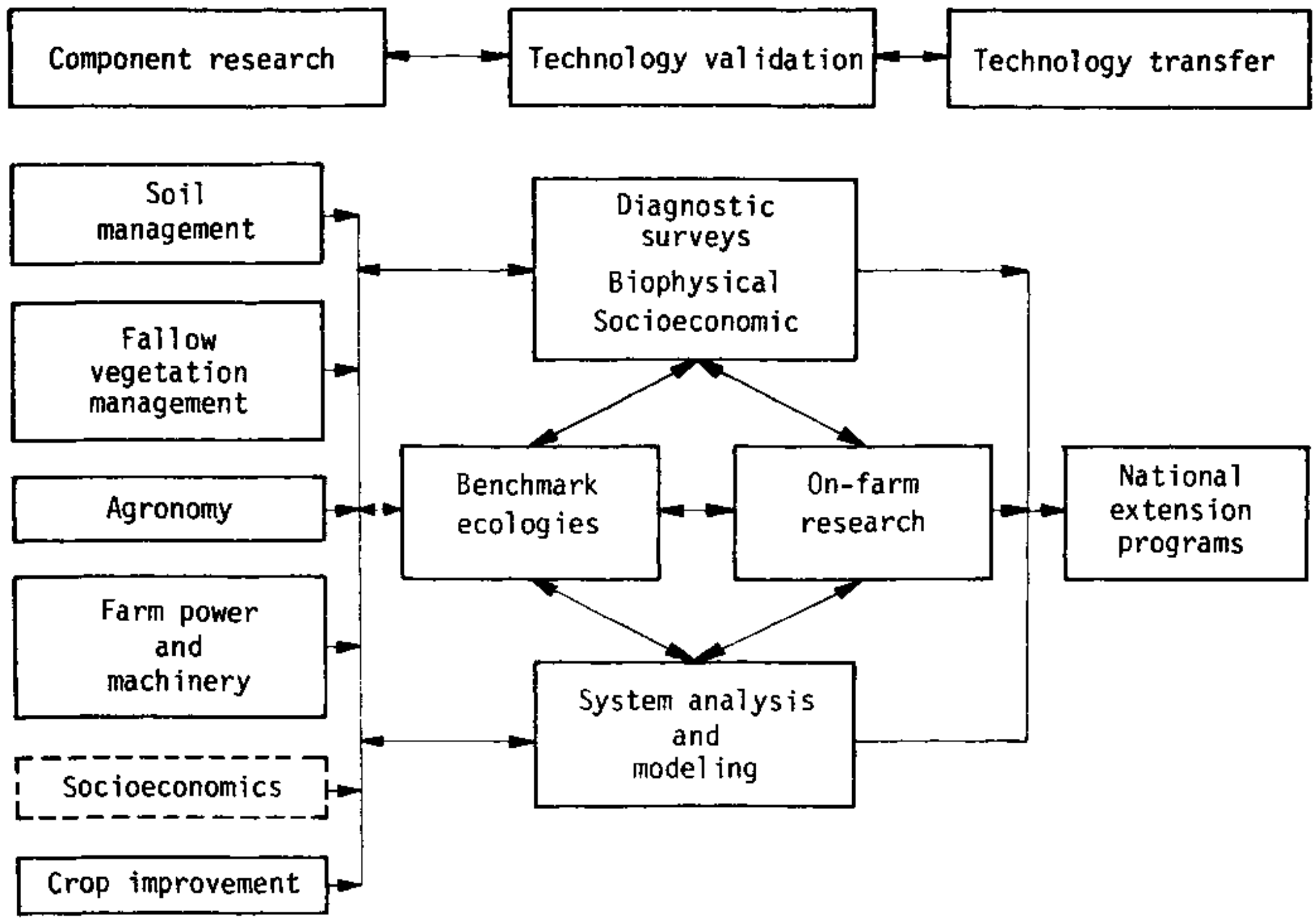


Figure 1. Functional activities and interrelationships among teams involved in FSR at IITA.

Research approach

IITA's research is carried out by at least three interdisciplinary teams: the diagnostic survey team, the systems component research team, and the on-farm research team. Figure 1 shows the interrelationships among them and with the national systems.

IITA's experience and progress

A new technology may be a simple component, a subsystem, or a whole package. Examples of simple and complex improved technologies developed at IITA include the following:

- Improved varieties, e.g., a cassava variety resistant to bacterial blight and mosaic, a 60-day cowpea variety, a streak-resistant maize variety, and hybrid maize.
- Intensified cropping systems for smallholders, based on improved cropping patterns, e.g., mixed cropping combinations with cassava/maize, cassava/cowpea, and maize/soybean.
- Fertility maintenance through a mucuna cover crop or through the integration of food crop annuals with woody perennials, as in alley cropping systems.
- A no-till package for grain crop production to minimize soil erosion, improve soil physical conditions, and reduce labor inputs.

Component research

IITA's farming systems research in the past has focused on the analysis of the existing farming systems, systems component research, and new farming systems development. More recently, an on-farm adaptive research component has been added in collaboration with the national agricultural research service. Against the background of weak NARSs and a limited knowledge base in the region, efforts were concentrated on developing technical information to enhance understanding of the local biophysical environments. New technology has been developed towards land clearing and development, methods of seedbed preparation, management of acid soils, alley cropping and agroforestry, wetland management, and improved cropping systems.

Introduction of an improved variety, with characteristics that alleviate specific constraints within the traditional system, can bring a significant increase in production. Improved varieties, however, must fit into the desirable cropping/farming systems that permit the land to be used intensively for sustained production. These technologies are developed as low-input technologies designed to conserve soil and water, maintain fertility, and meet protein requirements for balanced human nutrition. The welfare of rural women is receiving attention, and IITA is developing improved varieties with short cooking time, readily accessible sources of fuelwood and fodder, and improved storage and food processing technologies.

The improved systems of land clearing and mulch farming enhance the productivity of tropical soils for intensive cultivation for 3-4 years, followed by 1-2 years of planted fallows. In combination with improved varieties, management practices can double, even triple, the present yields of the bush-fallow system, with little soil and environment degradation. Some examples of improved technologies are shown in Table 1.

Table 1. Examples of IITA's improved technologies and their features.

	Cropping system based on:			
	Root crops	Maize	Rice	Plantain
Land Clearing and Development	*	*	*	*
Soil Productivity Sustenance				
(a) No-till				
(b) Mulch farming	*	*		*
(c) Alley cropping	*	*		*
(d) Crop rotation and mixed cropping	*	*	*	*
Weed Management				
(a) Chemical control	*	*	*	*
(b) Biological control	*	*		*
(c) Rotational control	*			
(d) Plastic mulching	*	*		*
Labor Efficiency				
(a) Hand tools/equipment	*	*	*	
(b) No-tillage/ herbicides		*	*	
(c) Partial mechanization	*	*	*	
Food Supply/Nutrition				
(a) Mixed cropping	*			
(b) Rotation	*	*	*	
(c) Dry-season catch crop			*	
(d) Storage facilities				
Drought-resistant Varieties	*	*	*	
Disease/Pest-resistant Varieties	*	*	*	*
Consumer Preference				
(a) Seed color	*	*	*	
(b) Cooking quality	*	*	*	
(c) Fuel efficiency		*	*	
(d) Storability		*	*	

* Component or subsystem research developed/adapted by IITA.

International cooperative projects

In collaboration with NARSs, outstanding progress has been made in developing cooperative programs in validating component technologies in diverse agroecologies in 10 countries; in addition, the Farming Systems Program has also developed linkages with many agricultural development projects.

Conclusions

IITA's past 16 years of research has provided a broad knowledge base about the humid tropics regarding traditional farming systems and their biophysical environments, potentials, and constraints to improved production systems, and cultural practices to fit new cultivars into improved systems. IITA has also initiated on-farm research through linkages and cooperative programs with national agricultural research centers.

In sub-Saharan Africa, meeting the mounting food deficit is particularly challenging. However, the prototype technologies generated by IARCs can be adapted to improve food crop production. IARCs could jointly develop farming systems networks to organize technology transfer in each of the major agroecological zones. Regional workshops, symposia, and training courses may also be jointly organized. Component or disciplinary research should be so organized as to provide answers to specific problems, e.g., soil and climatic constraints, productive cropping systems, and cultural practices for improved varieties.

There is a need to develop (1) energy-efficient tillage systems and improved tools, (2) methods of alleviating soil compaction and erosion control, (3) technology to utilize wetlands more effectively, and (4) agroforestry-based systems to maintain soil fertility. Particular attention is needed to develop sustainable cropping systems that also facilitate mechanization. There is a tremendous scope for interinstitutional cooperation in developing effective research programs along these lines.

Farming Systems Research at ICRISAT

ICRISAT Staff

Introduction

The need for area-based research to develop and improve farming systems in the rainfed semi-arid tropics (SAT) was clearly identified when ICRISAT was first established. In these regions of low and erratic rainfall and poor soil fertility, stable sustainable production—without environmental degradation—is as important as higher yields.

In this paper we describe the approach and research thrusts of ICRISAT's area-based FSR in the semi-arid tropics.

Objectives

Two of ICRISAT's four mandate statements embody general FSR objectives:

1. To develop improved farming systems which will help to increase and stabilize agricultural production through better use of natural and human resources in the seasonally dry semi-arid tropics.
2. To identify socioeconomic, physical, biological and other constraints to agricultural development in the semi-arid tropics and to evaluate alternative means of alleviating them through technological and institutional changes.

Eight other specific objectives were outlined in the special review of FSR in 1981.

Approach and Emphasis

In India, its area-based FSR, ICRISAT has given more weight to FSR (sensu stricto) and new farming systems development (as defined by Simmonds) than to commodity-based on-farm research. The small watershed has been used as an effective locus for integrating interdisciplinary research, especially on land and water management.

In West Africa, however, the approach is much more in consonance with on-farm adaptive research. Collaborative studies on crop-livestock interactions are an integral part of it, and the importance of the toposequence in conditioning farming systems is clearly recognized.

Nevertheless, despite differences in emphasis, our FSR in India and West Africa is based on a common approach, the central element of which is long-term research on benchmark sites in target environments.

Target Environments and Benchmark Sites

ICRISATs farming systems research has focused primarily on the "dry" semi-arid tropics (rainy season 2.0-4.5 months). We use a two-way matrix based on annual rainfall and soil type to delineate fairly homogeneous target environments—a prerequisite for selecting benchmark sites in the widely diverse environments of the SAT.

Four major groups of soils have been identified as important: Vertisols and related Vertic soils; Alfisols; sandy soils of the Sahel; and Oxisols and related soils. One problem in delineating target zones is the lack of a soil taxonomic system that is commonly used by all countries in the SAT.

Long-term socioeconomic studies in India and West Africa provide a common framework to address issues of production constraints and technology adaptation.

Improved Vertisols Technology: A Case Study

FSR began at ICRISAT in 1972, with field experiments which, despite the severe drought that year, demonstrated the scope for double-cropping in Vertisols that traditionally were used for only one crop, after a fallow during the rainy season. One important finding was the advantage of dry-seeding sorghum just before the rainy season to avoid shoot fly damage; primary tillage, however, had to be done immediately after harvest of the previous postrainy-season crop.

A broadbed-and-furrow system was evolved that reduced runoff from 33 to 10% of rainfall; grassed waterways reduced erosion and waterlogging; and runoff collection ponds provided supplemental water for use during dry spells in the monsoon and for the postrainy season.

Improved cropping systems and crop combinations were systematically tested, and the most stable and profitable was found to be sorghum intercropped with medium-duration pigeonpea. Base-data analysis, using rainfall and soil water storage capacity to predict the length of the growing season, helped in the selection of other crop options.

Three clusters of components—cropping systems, nutrients, and agronomic management—were recognized as being particularly important to an improved production system. Profits were increased most consistently and significantly by the interaction of high-yielding varieties and inorganic fertilizer.

Operational-scale research was begun with prototype improved systems. Two watersheds have been maintained under the same system of management since 1976, providing a comparison over a 9-year period of the improved practices versus the traditional rainy-season fallow and single postrainy-season crop. Under the improved system the findings were as follows:

1. Agronomic productivity was significantly increased (Table 1) and runoff and erosion markedly reduced; soil loss from erosion dropped by 77%.
2. Annual profits averaged Rs 3650 ha^{-1} vs Rs 500 ha^{-1} (US$ 304 vs 42).
3. The rate of return on extra investment in the improved system averaged 250%.
4. Labor requirements increased, offering a potential source of increased employment (about 250%) for landless laborers and small farmers.

Verification

Initial on-farm trials in village-level-study benchmark villages showed that, while some components significantly increased yields at some sites, the total package was not profitable, except potentially on the "wet" Vertisols. Diagnostic studies further refined the distinction between dependable and undependable rainfall regions on the Vertisols. Subsequent verification trials have focused on three contrasting rainfall regimes within the wet Vertisols. Returns on investment over 4 years have averaged 240%; development costs of the on-farm watershed ranged from Rs 200 to Rs 1000 ha^{-1} (US$ 17-83), much lower than investing in irrigation schemes. These trials also showed us key areas in which component research had to be strengthened: for instance, pest control in pigeonpea, and grain mold and *Striga* control in sorghum.

The verification trials were carried out in collaboration with the State Departments of Agriculture, and several institutional problems were identified in the process.

Table 1. Grain yields under improved and traditional technologies on deep Vertisols at ICRISAT Center in 9 successive years.

Year	Cropping period rainfall (mm)	Grain yields ($kg\ ha^{-1}$)			
		Improved system: double cropping		Traditional system: single crop of	
		Cereal and	Pulse	Cereal or	Pulse
1976-77	708	3204	717	436	543
1977-78	616	3076	1223	377	865
1978-79	1089	2145	1256	555	532
1979-80	715	2295	1195	500	450
1980-81	751	3587	920	596	563
1981-82	1073	3194	1047	635	1046
1982-83	667	3269	1095	630	1235
1983-84	1045	3051	1766	838	477
1984-85	546	3355	1014	687	1232
Mean	801	3020	1137	587	771
Standard deviation	209	482	289	138	327
c v %	26	16	25	24	42

Double-cropping consisted of rainy-season cereal (maize or sorghum), and postrainy-season pulse (sequential chickpea or intercropped pigeonpea).
Traditional cropping of one crop only of sorghum or chickpea in the postrainy season with no pest control.
Average annual rainfall (1901-70), 760 mm with CV of 24%.

Transfer and Impact

Since 1982, the Departments of Agriculture in four states have carried out small watershed verification trials. ICRISAPs role has been chiefly advisory, hosting seminars and training programs.

A key institutional question to be resolved is whether the watershed-based technology options can be transferred through the existing delivery and support systems or whether a project approach would be more effective. Besides the direct impact on production, the new technology options (together with others from the Indian national program) appear to have influenced policy decisions by central and state governments to invest in a watershed-based approach to improving dryland agriculture.

Lessons from the Vertisol Experience

Of the eight FSR objectives outlined, the ones most successfully met have been (1) carrying out research on new practices, principles, system components, subsystems or cultivars within a farming systems context, and (2) assessing prospective technologies on farms in priority regions and strenghtening linkages between research, extension, infrastructural support systems, and development agencies. Other objectives have been partially met.

The issue of how to increase cost-effectiveness of on-station research is largely ignored in FSR. ICRISAT's increased linkages with universities and other institutions have helped support on-station FSR in national programs.

The approach taken in the wet Vertisols of India may not work as well in other SAT areas where the potential for exploiting underutilized resources is not as great. In certain environments, FSAR may give a higher payoff.

Another strategic consideration is the appropriate locus for research. The extent to which institutional transfer capacity should influence choice of the locus for research also needs consideration. Our Vertisol experience suggests, unfortunately, that production potential is not highly correlated with transfer potential.

On-farm and On-station Research

Allocation of resources to on-farm and on-station research differs markedly between ICRISAT's FSR programs in India and Africa. On-farm research is emphasized more in Africa. In India, attention is focused more on area-based technology generation.

Methodological content of on-farm research also differs between the two regions. In India the large-scale verification trials have sometimes made it difficult to measure the performance of individual components on farmers' fields. In West Africa, on the contrary, the farmer's field is the focus of OFR.

National Program Linkages

ICRISAT links its FSR to activities of national program scientists through international workshops, collaborators' and consultants' meetings, training programs, and graduate thesis research. Short-term staff appointments of national program scientists is another avenue for improving our understanding of institutional constraints and capabilities.

Looking Ahead

The principles of Vertisol technology developed in India will be transferred to other countries, especially Sudan and Ethiopia, which have large areas of Vertisols. Increasingly, ICRISAT's research will be framed within the network of IBSRAM (International Board for Soils Research and Management). Transfer will involve communicating principles; the emphasis will be on base-data analysis and related diagnostic research.

In India, research resources will now shift to the medium- and low-rainfall Vertic soils and sandy Alfisols.

Sandy soils of the Sahel will receive considerable attention and resources will concentrate on the Sahelian Center at Sadore.

Commodity Program Linkages

The productivity of area-based FSR at the IARCs is intimately linked to the health of commodity improvement, both in the IARCs and national programs. For instance, improved soybean varieties have been a vital ingredient of the double-cropping experiments in Madhya Pradesh.

Activities

Core activities in the future will continue to have the following emphases.

1. Comparative evaluation of research done elsewhere.
2. Widespread use of simple models to test a range of alternative hypotheses.
3. Mapping based on review and simulation work for various production techniques such as dry seeding.
4. Determination of uniform data sets to be collected in multipurpose or omnibus experiments.
5. Increased cooperative research at national program centers and on farms.

Although these activities are both difficult and time-consuming, a proper balance must be maintained between such review and synthesis on the one hand, and field experimentation on the other, to get the maximum benefit from area-based farming systems research.

Farming Systems Research at ICARDA

K. Somel and P. Cooper[1]

Introduction

The International Center for Agricultural Research in the Dry Areas (ICARDA), located near Aleppo, Syria, has a regional mandate covering West Asia and North

1. International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria.

Africa and a global mandate to coordinate research on barley, lentils, and faba beans. ICARDA also conducts collaborative research on chickpeas (with ICRISAT), and wheat (with CIMMYT), and in pasture and forage improvement and livestock management.

ICARDA's mandate is based on the concept of FSR; thus the Farming Systems Program and the Center share a common ultimate goal of increasing both the level and the stability of production, in a region characterized by great seasonal variation in climate and by diverse social and economic conditions.

Goals and Long-range Objectives

Interdisciplinary research is integral to the Farming Systems Program and ICARDA activities. An agricultural system is determined by its natural and human resources, its historical development, and current social and economic environment. Due to the large and diverse nature of ICARDA's region, these combinations of factors result in numerous different systems, each unique in its own way. FSR does not aim, therefore, to develop an improved system of wide applicability. The program has the following long-range objectives.

- To establish an FSR methodology which can be demonstrated successfully in our core research in Syria. This objective has been largely met during the last 3 years. However, the need to maintain some flexibility in the methodology, as experience dictates, and the time required to thoroughly demonstrate the success of the methodology, both require that this remain a major objective in the immediate future.
- To conduct research for development of improved farm practices as components of improved systems.
- To foster the initiation of FSR within ICARDA's region through cooperative projects with national programs and through training of regional personnel.
- To assess and demonstrate the regional applicability of the results of our technical core research program through the use of a comprehensive agroecological zonation process.

Research and Training in the Core Program

The Farming Systems Program aims to increase the productivity, profitability, and stability of agricultural production through research both on improved practices and increased cropping intensity. Crop/livestock interactions, rotations, agricultural labor and mechanization issues, climate and soils, and the policy environment are considered in research. The Farming Systems Program is now organized into five research projects.

1. The barley/livestock systems project in areas with less than 350 mm annual rainfall. This includes work on barley productivity, livestock management (mainly sheep), rotations to introduce forage legumes into barley fallow or continuous barley.

2. The wheat-based systems project in areas with more than 350 mm annual rainfall where wheat, food legumes, and summer crops predominate. Wheat is a major crop in our region and much of our work focuses on it. Our work on food legumes includes on-farm evaluation of new production technology: early sowing of lentils, mechanized harvesting of lentils, and winter sowing of chickpeas.

3. The intersystem research project aims to provide quantitative information on the effect of variability in climate, soils, and socioeconomic conditions on the farming systems of the region, and to provide a basis for the extrapolation of research results from a limited number of locations and seasons, to other similar locations or environments that may differ in known respects. Some examples of research activities in this project are: phosphate reaction in calcareous soils; supplementary irrigation, agroecological zoning and modeling; regional standardization of soil analyses; supply response analyses for principal ICARDA crops, etc.

4. The project on cereals/livestock systems in Tunisia focuses on agricultural and socioeconomic constraints faced by small farmers in Beja Province in a wheat/ barley/ livestock farming system. The bulk of this work is conducted by Tunisian national scientists based in INRAT and INAT.

5. The training and agrotechnology transfer project is to be expanded substantially in the coming years. Training activities in FSR fall into three major areas, namely: training workshops focusing on particular farming systems research issues; short- to medium-term training courses (in-country or at ICARDA) for groups of trainees from countries in which FSR is being conducted; and long-term training for postgraduate students from the region. In addition to these major areas, ICARDA scientists continue to visit countries in the region in which ICARDA projects are either under way or are planned, to assist national scientists in the design, execution, and interpretation of their work.

International Cooperation

In addition to our considerable training program, ICARDA's collaborative research with national programs is also increasing; in Tunisia it is now well established and we have also initiated collaborative research with the Soils Directorate of the Ministry of Agriculture and Agrarian Reform in Syria to investigate improved crop productivity in barley/livestock farming systems in northern Syria. An additional FSR project based in the northwest coastal area of Egypt is currently being considered for funding, and a strong involvement in high-altitude farming systems in Pakistan has commenced with the USAID-funded project at the Arid Zone Research Institute in Quetta, Baluchistan, this year.

In addition to these major associations with FSR projects in Syria, Tunisia, Egypt, and Pakistan, we have also developed smaller component-specific research projects with several countries.

Fertilizer Use on Barley: A Case Study

Barley is an integral part of the farming systems of the drier regions of West Asia and North Africa, where it is the principal feed crop in the integrated crop-livestock systems. Livestock production (mainly sheep and goats) is important for meeting growing urban demand and as an important source of calories and protein in rural diets. In the dry areas, barley has a comparative biological advantage due to its higher drought adaptation, and the barley/sheep system is a time-tested activity with few alternatives in the dry areas.

Initial trials focused on optimizing the efficiency of use of the most scarce factor in agricultural production in the dry areas—water. Investigations on potentially important management factors showed that fertilizer, principally phosphate, gave consistent and substantial increases in both grain and straw yield. Even in very dry years, substantial responses to fertilizer were obtained *with increases in water-use efficiency but without a corresponding increase in water use.* In contrast to low water-use efficiency (20-25%) under farmers' current management practices, with improved management water-use efficiency increased to over 80%. Thus there is great potential for both improved crop productivity and profitability, as well as lower yield variability, through fertilizer use and consequent improved water-use efficiency.

It was also found that the crop rotation (fallow-barley or barley-barley) substantially affects responses to fertilizer and this must be considered in assessing economically optimum fertilizer recommendations. In general, using multiple-season, multiple-location trials and long-term climatic data, it was found that fertilizer use would pay around 80% of the time and that marginal rates of return over 150% would be required to encourage fertilizer use.

Collaborative Research

With growing interest in these developments and research results, in 1984 a workshop was sponsored jointly by the Soils Directorate of the Syrian Ministry of Agriculture and Agrarian Reform—which has the mandate for making fertilizer recommendations in the country—and FSP/ICARDA. As a result, a collaborative on-farm project was started on testing N and P fertilizer use on barley. In Syria, fertilizer use on barley in the dry areas is discouraged as a matter of policy. However, based on the tentative results of 1 year's trials, cooperating Syrian scientists have now instructed state farms in dry areas to use fertilizer on barley on an experimental basis. This would indicate a stir in the direction of policy changes, further evidenced by the extension of agricultural credit to the intermediate dry zones.

Conclusions

ICARDA, in its 9 years of existence, has tried to meet the challenge of developing research results to meet the urgency of the agricultural problems faced in the region. An interdisciplinary FSR perspective has helped understanding of the complex farming systems of West Asia and North Africa. The FSR perspective has allowed us to identify and focus on critical elements in these systems that can precipitate change. The farming systems program is gradually moving into collaborative research projects with national scientists, to produce concrete results. These activities are being backed by ICARDA's efforts in producing improved cultivars, agroecological zoning and targeting, as well as policy research.

An example is our research on barley, an ICARDA mandate crop. In this area, the FSR perspective has allowed us to produce viable results in a short time. We are using and anticipate continuing to use this approach profitably in many areas of research in the West Asia and North Africa region.

Review

N. Hudson[1]

I shall try to highlight some of the similarities and differences between the FSR programs of the three area-based Centers.

The objective of all three programs is stated as being to increase productivity. I would like to point out that there may be other objectives, such as to increase the reliability of production, or to reduce the labor requirement, or to increase the efficiency of the labor force, or even to increase production of cash crops to generate foreign exchange.

We have had several references to land capability and soil conservation. A common constraint is the lack of a coherent national policy for land use and resource development. The IARCs will not wish to become embroiled in national politics, but this constraint is not going to go away, and should be recognized.

In Session 1, Plucknett and Dillon suggested separate mandates for the commodity-based and resource-based programs, and the three papers suggest that this is a valid point. In all three, it is not clear how the FSR programs will interact with the other programs. The descriptions of the process, for example, "we will cooperate with" or "in close liaison with," are too vague.

Similarly, all three papers talk of working with national programs, but do not explain just how this will happen. So I support the suggestion by Dr Castillo that this matter should be given more attention.

Another aspect that is given inadequate attention in all three papers is the forward planning of FSR. There should be defined targets against defined time scales.

We have had discussions on terminology. If one accepts the concept that "it's not science until it can be (a) defined and (b) measured," then FSR has a long way to go on both counts. The confusion of terminology does not worry me, for it is only jargon—a shorthand used by specialists when talking to each other. The problem arises when, as

1. Silsoe Associates, Ampthill, Bedford, UK.

in this case, the specialists find they cannot communicate with nonspecialists without using the jargon, which the nonspecialists do not understand. This is the problem of FSR at the moment and it does require attention. (What would be more serious would be if excessive jargon were used to cover up lack of precision in the thinking.)

On the suggested "harmonization" of the IARCs* FSR programs, I agree with Dr Castillo (Session 1), that there is no need for this. This afternoon's papers show that the I ARCs are all doing different jobs, in different conditions, and I think it is right and proper that they should each develop their own approach to FSR, their own style (even their own jargon if they wish).

Some of the differences between the three Centers are as follows.

1. The rates of change they are seeking. ICARDA is looking for step-by-step improvements, whereas ICRISAT and IITA are closer to NFSD; but Lal (IITA) argued that NFSD can also be stepwise, so perhaps the difference is not important.
2. The degree and manner of cooperation between IARCs and NARSs varies a great deal, and this is to be expected, since the capacity of national programs also varies greatly.
3. IARCs with FSR programs have to allocate resources to the various parts of the program. The ICRISAT paper includes a table (Table 1) that shows the number of personnel engaged on each activity in 1978 and 1985. It would be useful if (a) this could also include a projection of the expected allocation in 5 years' time to further demonstrate the trend, and (b) the same data could be supplied from other IARCs.

The ICRISAT paper highlighted the problem of transferring technology after it has been developed and validated. This is an important point which could be given attention by the other IARCs.

Chairman's Summary

N.W. Simmonds[1]

The three programs (ICRISAT, IITA, and ICARDA) represent three strongly contrasted approaches to FSR. Collectively, they illustrate very well the observation of the TAC Stripe Review (echoed by later writers) that IARC approaches *are* diverse by reason of mandates, histories, and local agricultural interests.

Broadly, the following generalizations seem justified (admittedly with some simplification).

1. ICRISAT has a long-established program that is essentially ecologically and technically oriented, is systems-based, has had a relatively small economic input, and started its OFR work relatively late. (But extensive village studies were conducted in parallel early in the life of the program.)

1. Edinburgh School of Agriculture, Edinburgh, UK.

2. IITA has a long-established program that is component- based, the intention being that components of land management, weeding, small-scale mechanization, new varieties, etc., should be fitted together stepwise into new or adjusted farming systems in the wetter tropics. Thus far, the economic input and OFR activities have been relatively small, but the latter, we heard from Dr Lal, were developing strongly.
3. ICARDA initially stimulated several studies of Mediterranean agriculture that were essentially of an FSR (sensu stricto) nature but later moved towards a strong OFR/ FSP orientation. Indeed, Dr Somel explained that ICARDA does far more work on-farm than on-station.

Additional information given in the ICRISAT paper shows that, in recent developments of its work in Africa, it has moved strongly towards an OFR/ FSP approach. Dr Virmani explained this as being due to the Center's belief that this was appropriate to the African circumstance, whereas, in India, there was a strong national system in place and ready and eager to undertake the on-farm exploitation of ICRISAT findings. He explained that the national system was at the point of large-scale exploitation of watershed management systems for black soils. He added that the ICRISAT program is soon to be reconstructed as the Resource Management Program, to include a closely integrated economics component.

In retrospect, I think it is fairly clear that the three Centers were largely constrained by mandate and location to adopt the lines of work that they did : ICRISAT to enhancing the productive potential of the black soils, IITA to the local realities of poor lands increasingly stressed by overexploitation, ICARDA to the dominance of migrant sheep in very dry places.

In retrospect, also, one wonders what would have been the effect if ICRISAT had begun its studies on-farm earlier: perhaps the toolbar technology would have been modified? One wonders also what will be the outcome for the ICARDA plant breeders of OFR studies of new varieties: given the overriding fact of irremediable drought, what can plant breeders do if there is little or even no scope to exploit genotype x environment interactions? And, again, one wonders which elements of the IITA component studies will prove to be exploitable in agricultural practice? Alley cropping looks likely, but will farmers adopt it and in what contexts?

At risk of being told that I am riding a hobby-horse, I now refer to New Farming Systems Development (NFSD.) The need for fundamental change in shifting/fallow systems in the lowland wet tropics figures in the IITA mandate, yet the available components (some of which seem potentially very promising) have yet to be synthesized into any semblance of an NFSD. Bold acts of imagination are required; but where are they to come from? Scientists, governments, and institutions will all have to be involved. Dr Lal argued that stepwise adoption of components will be feasible; with respect, I doubt it. I believe that any effective NFSD for these circumstances must involve the extensive use of tree crops for food, an annual-perennial swing so to speak. Yet we are essentially ignorant of tree food crops. The point emerges elsewhere in this meeting (Session 5) and I personally hope that one result of our discussion will be to direct TAC/ CGIAR attention to the neglect of perennials. Bananas, it is true, are just starting to emerge from ill-deserved obscurity, but the food trees are still terra incognita to most tropical agricultural research organizations (with honorable exceptions such as CATIE and some NARSs).

Session 3

Commodity/Input-based Farming Systems Research

3 (a) Chairman: N.S. Randhawa
Rapporteurs: K. Somel, ICARDA/R.A.E. Muller, ICRISAT
Reviewers: A.A. Gomez

3 (b) Chairman: P.R.N. Chigaru
Rapporteurs: M. Upadhya, CIP/K.B. Laryea, ICRISAT
Reviewers: M.H. Arnold, and J.G. Ryan

Farming Systems Research at IRRI: an Overview

IRRI Staff

Introduction

Farming systems research at IRRI is designed to help the Asian rice farmer who farms less than 3 ha, has limited capital, and uses human and animal power for most field operations. Cropping System Program staff study rice-based farming systems and develop technology that farmers can use to intensify cropping to produce more food, increase farm income, and generate additional employment. Crop diversification can also improve the nutrition of farm families.

Cropping systems research began at IRRI in 1965. Early research demonstrated that rice farmers were not always using their soil and climatic resources to capacity. However, the early cropping systems tested on the IRRI experiment station were too complicated and required too many inputs for small farmers to accept.

On-farm Research

Twelve years ago, IRRI began to develop and test intensified cropping systems that would be acceptable to the Asian rice farmer, particularly on the small farm, under rainfed conditions. To test farmer acceptability, on-farm research methods were developed and used as a complement to conventional on-station research, to answer these questions:

- How fully are crop physical requirements met under farm conditions?
- Does the farmer have sufficient resources and skills to cope with necessary cultural practices?
- Can a new cropping pattern compete with current land use?

Valid answers to these questions cannot be obtained efficiently from research conducted entirely on experiment stations; close association with farmers is needed for realistic assessments of the physical, biological, and socioeconomic environments in which farmers produce crops for subsistence and sale.

In IRRI on-farm cropping systems research, multidisciplinary teams design and implement projects for target environments, especially disadvantaged environments. Most commonly, not enough water is available to use on the land year-round. Similarly, flooding can be a hazard to rice and to crops grown before and after it.

The following on-farm research methods were developed cooperatively by IRRI scientists and national scientists of Asian countries which participate in the cropping systems network.

Selection of sites with potential

The target area for research should represent a large agricultural area with similar physical and socioeconomic characteristics. National governments or policymakers should recognize the target area as having potential for significant agricultural development.

Site description

Description of the research site involves securing and studying secondary information on climate and soil. Surveys and interviews are conducted to determine the current farming practices and land, labor, capital, and power resources.

Design of new cropping systems

Armed with site description information, the cropping systems team discusses its ideas with farmers, and then designs new cropping patterns for the most common land types in the target area. The cropping patterns to be tested are blends of traditional practices and new technologies and are adjustable within environmental limitations and farm resource constraints. All disciplines are involved in the design stage, since "cropping systems" includes all production components required to cultivate a sequence of crops on each land type. The design ensures that farmers can provide feedback on the new systems. Socioeconomic studies are undertaken simultaneously, to ensure that the changes in cropping systems do not conflict with other farm activities, e.g., animal management, or with social conventions.

Testing new cropping patterns

New cropping patterns are compared with the farmers' current patterns. Farmers provide land, labor, and power for the new patterns. Four to six cropping patterns are tried in the first year. Those showing poor economic returns or farmer acceptance are discarded; promising ones are tested further. Each field represents one replication, with at least five replications per land type.

Simple superimposed trials replicated across cropping pattern test fields, and researcher-managed trials replicated within fields are used to evaluate component technologies such as varieties, insecticides, and fertilizers.

Multilocation testing

Technology acceptable to farmers in the initial research site is tested over the larger target area to verify its technical and economic superiority. This verification, or multilocation testing, is a joint undertaking of researchers, extension workers, and farmers.

Production program

To complete a cropping systems project, a clearly defined production program is needed. Production programs require restructuring and coordination of support services to facilitate adoption of the technology. This systems approach integrates the technology with support services such as extension, input supply, credit, and markets.

Experiment Station Research

The innovative on-farm research projects and the cropping systems network program have attracted much attention and some controversy. Yet three-fourths of the Cropping Systems Program resources are devoted elsewhere—to discipline-oriented research. This experiment station-based program continues to develop innovations aimed at overcoming constraints encountered by small rice farmers. Research focuses primarily on problems identified during on-farm research, but for which simple shelf technology solutions have not been found.

Crop and soil management

The program emphasizes three types of crop and soil management problems: poor crop adaptation to moisture extremes, labor- demanding cultural practices, and high fertilizer costs.

When cropping is intensified by forcing crops into the extremes of the growing year, conditions are suboptimal for crop growth. These suboptimal conditions can last for a few days, as with excess water after a heavy rain, or a few weeks.

To avoid such problems, crop varieties are tested for performance in selected environments. For example, IR 36, an early-maturing rugged variety, formed the backbone of cropping changes at lowland sites having favorable field-water regimes. At a partially irrigated site, several very early-maturing lines are reducing the cost of pumping water for double-cropped rice. Tests at an upland site with acid soils suggest that UPL Ri-5 performs well. In this same environment, an IITA cowpea has been adopted by farmers.

Farmers cultivating extensive areas where rainfall is not reliable do not accept modern photoperiod-insensitive varieties. Studies show that traditional variety seedlings more than 100 d old can be successfully transplanted without decreasing yields. This seedling age insensitivity enables farmers to transplant during surges of the monsoon when enough water accumulates to permit puddling and transplanting. To reduce flood damage, retaining the trait would confer seedling age insensitivity on a modern variety, delaying flowering to late in the wet season. Cultivars are being bred that have this trait.

Varieties of upland crops are tested for performance in selected environments. These upland cultivars originate from CIMMYT, IITA, ICRISAT, AVRDC, and from national crop improvement programs. As with rice, upland crop performance under suboptimal conditions at the beginning and end of the wet season are of interest.

Traditional labor-intensive cultural practices, appropriate for single-crop systems, constrain crop intensification. This can prohibit early planting to avoid hazards of later drought, or planting when soil moisture is ideal for tillage and planting.

The **IRRI** Engineering Department has developed small power tillers, threshers, and seeders that complement manual and animal-powered methods, reducing labor peaks. This equipment enables farmers to establish second crops more quickly, especially when large areas are cultivated with similar crop sequences.

Biologically fixed substitutes for inorganic N fertilizer are being researched. Economists have shown that most farmers, especially on rainfed and unreliably irrigated lands, cannot afford to buy sufficient fertilizer N to fully exploit yield potentials of modern varieties. Research has shown that for 5 consecutive years, incorporation of a 40- to 45-d green manure crop before transplanting rice increased yields by 1.5 to 2.0 t ha^{-1}. *Sesbania* species are well suited to the transition from dry to wet season. *S. rostrata* can accumulate up to 100 kg N ha^{-1} in <45 d, and on-farm trials to test acceptability show that farmers are interested in further experimentation with it. Farmers have observed how it increases rice yields and have found that incorporation is only slightly more difficult than incorporation of heavy weed growth. They are aware that it can save US$ 75 ha^{-1}, enough to pay for more than 40 d of labor, important where alternative employment opportunities are few.

Plant protection

Research has aimed at developing profitable, stable, and sustainable integrated pest control practices based on cultural, biotic, and chemical methods. Teams are monitoring long-term effects of intensive cropping patterns on pest occurrence as well as adoption of new pest control technology.

Three issues are: the high cost of chemical control, the sensitivity of pesticide effectiveness to management and physical environment, and the safety of persons applying chemicals and the danger of pesticides accumulating in farm products and in soil and water.

Cross-site research has advanced our understanding of factors contributing to pest populations in lowland and upland rainfed rice. On-farm research spanning various rice environments strongly suggests that the major reason why rice insect pests are more abundant in Asia is not the introduction of modern varieties but the increase in dry-season irrigation and its use to increase rice cropping intensity. More crops per year stimulate insect buildup.

Insect pest problems can be reduced by creating a rice-free interval of at least 45 d between crops at least once a year. This rice-free interval can be achieved by growing early-maturing varieties, planting large tracts of rice synchronously, and inserting nonrice crops into the rotation.

Integrated pest management (IPM) technology is being developed to alleviate pest insect buildup and avoid killing natural enemies of insect pests. IPM minimizes the amount of insecticide needed to protect crops. It requires that farmers learn simple principles, monitor fields, and learn how to measure the economic thresholds of insect pests.

Agricultural economics

Technology generation is the central focus of multidisciplinary cropping systems research. It uses a mix of on-station and on-farm research to design, test, and retest technology. Agricultural economists are conducting research to sharpen this focus.

Research on rainfed lowland farms with double-cropped rice has shown that labor use is highest during first-crop harvest and second-crop establishment. This analysis encouraged agronomists and engineers to seek labor-saving harvesting and establishment practices. Profiles of farmers' cash and credit resources helped to guide research on practices using realistic recurrent input levels.

Training

IRRI has given high priority to training personnel for farming systems research. In addition to a 6-month cropping systems course, taken by more than 400 trainees since 1974, several 2- to 4-week specialized courses have been offered.

The Network

When IRRI began on-farm research, governments of Asian countries were having similar thoughts on how to improve the lot of small farmers. To consolidate these ideas, an Asian Cropping Systems Network was organized.

The network started in 1974 with two members, the Philippines and Indonesia; it now has 15 members. The policymaking body consists of cropping systems leaders from each country, the IRRI program leader, and the IRRI network coordinator. Much of the on-farm research methodology was outlined at a series of working group meetings of scientists from network countries.

The network objective, as stated in the first meeting in 1974, was "to formulate methodologies and directions for cropping systems improvement and to design collaborative studies." Additional objectives are to develop farming systems technology for the major rice-growing regions in Asia.

Accomplishments

Accomplishments of the IRRI cropping systems research program are many. In Iloilo Province of the Philippines, a new cropping pattern changed the lives of farmers. It involved an early-maturing, pest-resistant rice variety, IR 36, and the practice of direct-seeding instead of transplanting. Where only 12% of the crop previously was direct-seeded, now almost 100% is, and IR 36 is grown on 98% of the land. Farmers' net income has increased about 30%.

Network members report similar successes, though less dramatic and extensive. On-farm research has also led to many changes in on-station research programs.

The CIAT Bean Program's Approach to Systems-based Research

J. Woolley and D. Pachico[1]

Introduction

The term "on-farm research" as used at CIAT covers a range of systems-based activities that (a) increase knowledge of and analyze farmers' circumstances, and (b) are carried out in farmers' fields, under conditions prevailing there.

Although CIAT has no farming systems program per se, three commodity programs—cassava, tropical pastures, and beans—conduct on-farm research. This paper deals with the bean program, which concentrates on-farm work in crop subsystems that include beans and associated crops, in geographical areas where growing beans is a key enterprise. Related studies off the farm, especially of marketing and consumer preferences in grain types, are emphasized more than is usual for crops handled by other IARCs.

Because beans are grown under widely diverse conditions, CIATOFR emphasizes testing general strategy rather than specific techniques, and tries to integrate technology adaptation on-farm with technology development both on-farm and on-station.

OFR work is done primarily through the national agricultural research services; even where it is a direct CIAT activity, the national systems are closely involved in the planning and execution.

Objectives

CIAT on-farm research has five objectives: to (1) build national capability in doing on-farm research that will aid technology development and adaptation; (2) diagnose production constraints to help set CIAT and national research priorities; (3) develop methodology and involve CIAT personnel on-farm; (4) develop new technology under farm conditions; and (5) test, monitor, and understand the adoption of technologies. Throughout, the final client is the national agricultural system.

Present Status

The basic model for on-farm research at CIAT has four stages: diagnosis, choice of trial content, experimentation, interpretation, and recommendation; and, finally, interface with extension.

1. Centro International de Agriculture Tropical (CIAT), Cali, Colombia.

Diagnosis

Microregions are mapped by climate, soils, and production data to determine potential study areas, and problems diagnosed using inexpensive and rapid techniques. Reconnaissance and survey, which include interviews with farmers and field observations of crops, use farmers' existing knowledge extensively.

Trial content

In designing trials, scientists who diagnosed the problems work with those who will be tackling those problems. All possible technological solutions are listed, and research priorities assigned according to potential benefits, ease of adoption, and ease of research. CIAT has designed forms and guides to help national researchers through this process.

Experimentation, interpretation, and recommendation

Five stages of trial are used: variety, exploratory, economic levels, verification, and farmer-managed trials (Fig. 2). The last show how compatible a new technology is with the farmer's system and how well he can manage it. From stage 3 on, economic evaluation is done for all trials; its success depends on accurate understanding, during diagnosis, of the farmer's objectives and production constraints.

Interviews are held with collaborating farmers during trials, and a follow-up interview after the cropping season succeeding the trials measures the rate of adoption and the performance of the introduced technology when its use is left solely to the farmer.

Interface with extension

OFR bridges the divide between research and extension; at CIAT, both research and extension workers are trained in OFR and work on OFR teams.

On-farm Variety Testing (OFVT)

OFVT is a simplified version of OFR, designed primarily for breeders and experiment-station scientists. It is used where initial diagnosis has shown that rapid, short-term impact can be expected with a change in variety and possibly some related simple changes in agronomic practices. It permits the rapid testing of new bean lines across a range of environments.

Unlike maize, for instance, beans—a hitherto neglected crop—show notable response to varietal improvement alone, even without a change in agronomic practices, especially because CIAT research follows a low-input philosophy that simulates small-farm conditions.

OFVT uses basically the same procedures outlined earlier for OFR, but may eliminate or combine some of them.

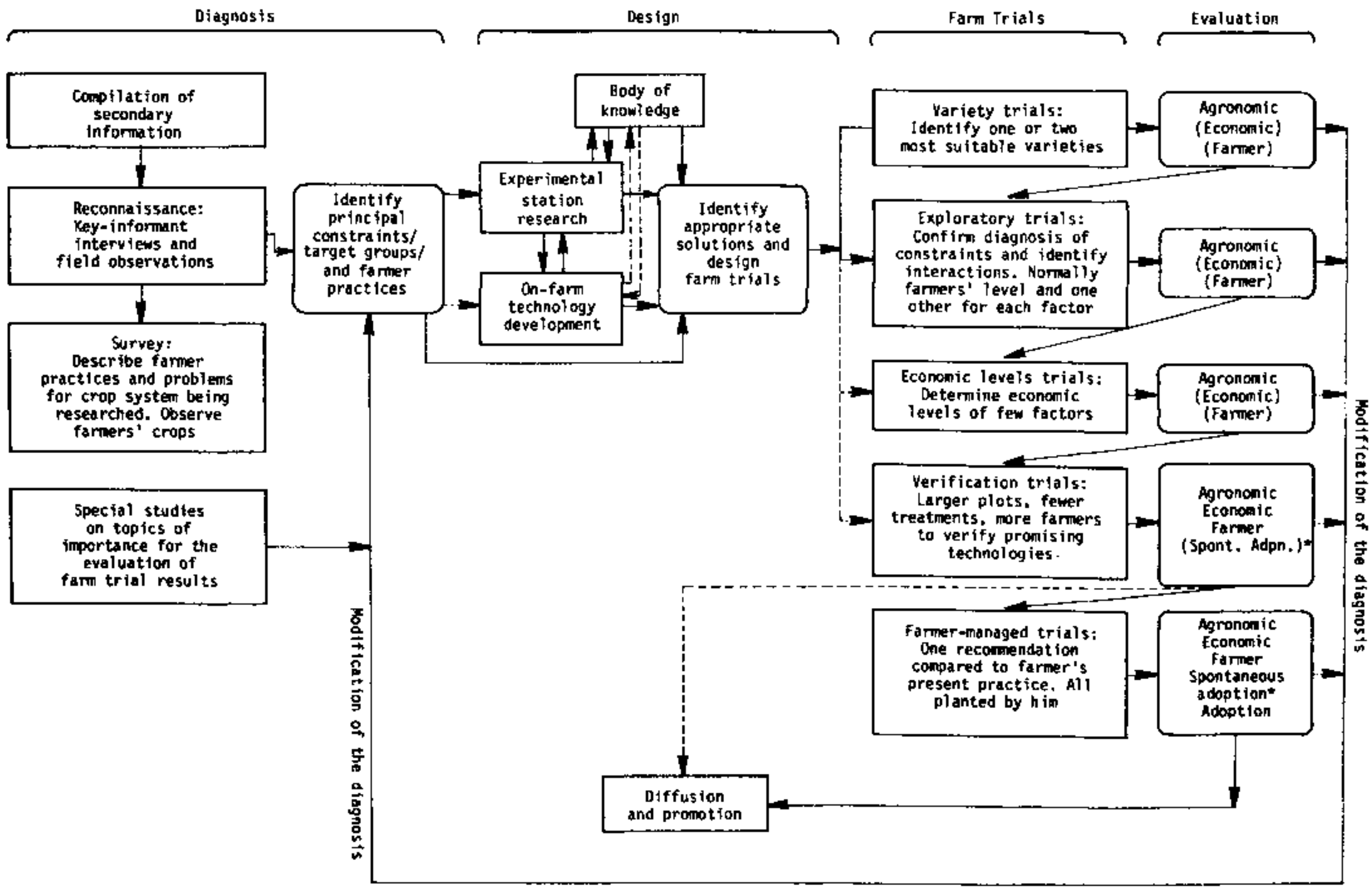


Figure 2. A conceptual framework for on-farm research being tested by CIAT and collaborators. Continuous lines show usual steps; broken lines show possibilities. *Spontaneous adoption by trial collaborators and adoption by farmers in general are measured at least one cycle after these trials.

Technology Development

While technology development may mostly be done on-station, some types of technology may need to be developed partly or wholly on-farm; for instance, soil fertility management or soil conservation practices. CIAT OFR uses farmers' fields as research sites to develop new technology with broad applicability, working either with a single component or with several interacting ones.

Input to On-station Research

On-farm research can significantly increase the effectiveness of on-station technology development by gathering preliminary information on farmers' prevailing practices and resources and by providing feedback on the performance of technology on-farm.

Studies of farmers' preferences on tradeoffs between yield and earliness or yield and grain types can guide relative breeding priorities; on-farm varietal trials can be used to refine selection criteria.

On-farm Research and On-station Research

The CIAT bean program does not develop new farming systems on-station. Results obtained on experiment stations, even those using farmers' cropping systems and input levels, often do not correlate well with those obtained on farms, perhaps because of differences in topology, soils, and previous agronomic practices. Station-farm comparisons confirm that such studies are better done on-farm from an early stage.

Linkages with National Programs

The final objective of OFR in the CIAT bean program is a national program network of research, feeding back to station research and forward to farmers' adoption of technology. Thus strong linkages are maintained with national programs throughout: in diagnosis and technology adaptation the bean program has an increasingly advisory role. In Colombia, the CIAT station-based breeding program is fully integrated with the national ones, and technology development on-farm is done in collaboration with the appropriate national program. For example, lines tolerant to bean golden mosaic virus were selected this way and have been released in several countries of Latin America, where they have proved additionally tolerant to poor soil fertility and water balance.

CIAT's on-farm researchers now spend over 50% of their time in training of national program scientists.

Achievements and Future Plans

While Colombia has been the base for the CIAT bean program for self-education, methodology development, and training in OFR, it has now been extended to other Latin American countries, sometimes in collaboration with IARCs.

In eastern and southern Africa, CIAT's regional strategy for bean improvement has a strong OFR component.

Results have now begun to show in Latin America. OFR procedures have been adapted and applied to beans, sole- or multiple-cropped. A training strategy has been designed to communicate the procedures and methodology developed, and various novel courses designed for OFR training.

On-farm trials have provided feedback to orient research priorities; for instance, breeding and selection to overcome low soil fertility, the major constraint to production. Follow-up surveys have shown that farmers usually adopt CIAT's new bean varieties with no changes in cropping system or inputs, thus validating the low-input philosophy of the research program. Unresolved problems also have shown up in these surveys and the reasons for poor adoption are being examined.

The most notable success of CI AT's OFR has been in Ipiales district of southern Colombia, where the new bean line, Frijolica 0-3.2, entered farmer-managed trials in the 3rd year, by demand from the farmers themselves. They noted that the new line, while of the same seed type as the widely grown Mortino, was higher-yielding, earlier-maturing, and also tolerant to anthracnose and root rots.

Thus there have been quick results and diffusion from the trials of a technology thought suitable by its ultimate user. Other genetic materials are also flowing from breeding station to farm trials in response to farmers' needs, and other new agronomic and pest and disease control recommendations are also being tested in verification trials.

A spinoff benefit from the Ipiales experiment is that it has demonstrated the effectiveness of OFR at the very time when planners are considering incorporating it into future plans.

We expect further demonstrations of the effectiveness of OFR in Latin America and Africa, which will indirectly contribute to the efforts being made in this direction by other IARCs to promote on-farm research and perhaps farming systems research in general.

Root Crop-based Farming Systems Research at IITA

H.C. Ezumah, S.K. Hahn, B.N. Okigbo, and T. Gebremeskel[1]

Introduction

The root and tuber crops, cassava, yam, sweet potato, and cocoyam, are important staple foods in Africa, supplying a large proportion of the calorie intake of the human population. They have potential as animal feed sources and industrial raw materials as well. The International Institute of Tropical Agriculture (IITA) has the world mandate for improvement of yams and cocoyams and a regional mandate for cassava improvement.

These crops are grown chiefly as subsistence crops, on farms less than 2 ha, using simple tools and no purchased inputs. Yields have increased over the last two decades but very slowly.

In Africa, root and tuber crops are invariably multiple-cropped with quicker-maturing crops and often in association with perennials. The chief constraints to increased production are: biophysical and technical factors (poor soil, diseases and pests, low-yielding varieties, and laborious cultural practices) and socioeconomic and cultural factors (lack of credit, inputs, processing facilities, and infrastructure). IITA's research is meant to address these problems.

IITA's Research on Root Crop-based Production Subsystems

Farming systems research at IITA is by mandate strictly cropping systems research. As such, it focuses on developing more efficient alternatives to the prevailing shifting cultivation. The program also emphasizes manpower training and collaboration with national programs.

A multidisciplinary team approach has produced 50 to 100% higher-yielding, disease- and pest-resistant varieties that are popular and widely adopted in Nigeria. Some sweet potato selections show promise for high yield with no fertilizer, resistance to weevils and virus disease, and wide adaptability. We have identified some blight-resistant lines of cocoyam, a hitherto neglected crop in which improvement is hampered by several factors.

Yam is a profitable crop in Africa. Cost of yam seed has been significantly reduced through mini- and micro-yam sets, a technique that has been widely accepted by Nigerian farmers.

Based on improved crop varieties, research has identified the most compatible combinations for cassava and yam in intercropping systems.

1. International Institute of Tropical Agriculture, Ibadan, Nigeria.

Yams, sweet potato, and cassava are incorporated in alley cropping systems in farmers' fields with *Leucaena leucocephala.*

FSR Activities at IITA

IITA conducts farming systems research in

a. base-line data collection and analysis of farmers' overall environment and prevailing farming systems;
b. experiment station work in developing, testing, and evaluating farming system component technologies;
c. testing, evaluating, and monitoring adoption on farmers' fields and obtaining feedback.

Linkages have been established with national programs, and we also have bilateral projects in various areas. Training in FSR is strongly emphasized at IITA and over 500 trainees—85% of them African—have taken our courses.

IITA's Experience

1. Base-line data collection surveys have shown us where to focus our research activity. For instance, women are the major cassava and cocoyam producers; men, the yam producers. Processing is done by women. These facts should be taken into account in developing technology and in directing extension efforts to the right targets.

2. On-farm adaptive research has given us information to re-orient our station research to improve the chances of adoption. For instance, sweet potato and cowpea have disappeared from some growing areas because of disease or pest outbreaks. Reintroduction of these crops must take this into account. Our mini- and micro-set seed yam technology was readily adopted because it closely resembles the common practice of "milking" and slicing the tubers to increase the seed yam.

Technology testing and evaluation

Testing and evaluation is done through (a) national programs, (b) bilateral projects in several countries, and (c) agricultural development projects. In Zaire, the Program National Manioc (PRONAM) developed gradually from a commodity base to a full FSR complex. The PRONAM model is internationally recognized and in Zaire has become a model for structuring research on food production.

Future of Root Crops in Africa

The FSR philosophy appears to be gaining ground in many African countries but continuing problems are, for instance, the shortage of trained personnel, especially extension specialists, socioeconomists, and women professionals; and the difficulty of communication between local farmers and expatriate staff. IITA therefore tries to keep its technology simple.

Yam and cocoyam cultivation has high labor requirements, which raise production costs; methods of reducing these costs must be devised if these crops are to compete with others. Developments in processing and marketing will also determine the future of these crops in the continent, because demand for them as now consumed decreases with increased incomes.

Root and tuber crops offer many advantages in Africa: they are easily cultivated across a range of environments, in soils unsuitable for other crops. Under drought and poor fertility, where other crops fail, root crops always give some yield.

Review (1)

A.A. Gomez[1]

My comments are organized into three main topics: (1) similarities and differences in FSR activities among the three Centers, IRRI, CIAT, and IITA; (2) opportunities for harmonizing FSR activities among Centers; and (3) other issues. The first two topics have a direct bearing on the objectives of this workshop, while the third allows me to comment on some issues that are of special interest.

Similarities and Differences Among the FSR Activities of IRRI, CIAT, and IITA

The FSR activities in the three Centers have major similarities, both in their objectives and their implementing strategies. There are, however, some differences in emphases. All three Centers recognize the development of improved technologies as a major objective. However, the objectives of developing research methodologies, as well as assisting national research centers, is prominently highlighted by IRRI and CIAT but is not formally stated in the IITA paper.

In terms of implementation, all three Centers conduct base-data analyses, on-station research (OSR) and on-farm research (OFR). However, there are major differences in emphasis. CIAT places major emphasis on OFR, to the extent of almost equating this activity to FSR; IITA, on the other hand, has very little OFR; while IRRI is somewhere in between.

1. University of the Philippines, Los Banos, Laguna, Philippines.

The three Centers operate their FSR through a fairly diverse organizational setup. IRRI has two separate departments whose primary responsibility is to conduct FSR; CIAT incorporates its FSR activities into existing commodity programs; and IITA lumps all activities apart from breeding into farming systems.

Opportunities for Harmonizing FSR Activities in the IARCs

While there is room for diversity among the various IARC programs on FSR, I also see the need to identify some key concepts or features that can truly justify a common label for all these programs. It would even be more useful if these key concepts can help harmonize the objectives as well as the organizational structures required to implement the programs. In this context, I see a major opportunity in the suggestion made by the concept paper of Plucknett, Dillon, and Vallaeys that farming systems research be looked upon as an approach to or a style of conducting research that gives prime importance to the farmers' perspective and requirements in developing new technologies. That is, research to develop new varieties or new fertilizer or pest management must be designed to solve existing farm problems and constraints rather than to achieve theoretical perceptions of potential productivity.

In this context, I see the existing strength of FSR in diagnostic base-data analysis as well as in the conduct of on-farm trials as an important and powerful tool in orienting and guiding the existing OSR in plant breeding or soils, say, to address existing and priority farm problems and constraints. If this notion is accepted, then the existing FSR programs should look forward to the following.

a. That the FSR perspective will be so successfully incorporated in all aspects of IARC research that separate FSR programs will be redundant.
b. That OFR will be an integral part of all IARC research in order to continuously remind the various on-station researchers of their FSR perspective.

Other Comments

On farmers' participation. Farmers' participation in OFR continues to be vaguely defined. This participation can take any one or a combination of the following forms:

- the farmer as part of the farm environment;
- the farmer as a judge who impartially watches the researcher conduct the experiment on his farm;
- the farmer as implementer of some specified activities in the research plot;
- the farmer as decisionmaker in planning the research;
- the farmer as decisionmaker in implementing the research.

Note that the level of farmer participation progresses from the first item to the last. Also note that the procedure for incorporating farmer participation increases with the level of his participation. Furthermore, the level of farmer participation may imply and even specify the focus of the experiment. Thus, it is necessary that the type of fanner participation be clearly specified before the experiment starts.

G ^{x} e interaction and the need for varietal improvement in farmers' fields. A significant genotype * environment interaction for trials conducted on-station and on-farm does not immediately justify the transfer of breeding work from station to farm. The size of this interaction and its relative magnitude with respect to the main effect of genotype and environment is important. The balance between on-station and on-farm evaluation as it relates to the relative magnitude of the various sources of variation has been published elsewhere.

Need for NARSs to have a farming systems perspective. The NARSs, who are mandated to solve existing farm problems, need a farming systems perspective much more urgently than the IARCs. How does the IARC help bring this about? Do we preach it? Do we show it? Can we now give some guidelines from the collective experience of IARCs? I think the decision of the various IARCs on the suggestion to identify key concepts in FSR will greatly influence what the NARSs will do.

I also feel that the emphases of the IARCs on OFR have greatly influenced the NARSs. There is no question in my mind that the OFR now being conducted in various NARSs is of substantial value in incorporating the farming systems perspective into their research programs.

CIMMYT's Approach to Systems-based Research

CIMMYT Staff

Introduction

The International Wheat and Maize Improvement Center (CIMMYT) has focused efforts on only one set of farming systems research activities—on-farm research with a systems perspective. CIMMYT sees its own role as providing research methods and training, rather than developing technology, for its clients, the national agricultural research systems. Our OFR usually concentrates on only one or two priority enterprises in the system at one time. This paper describes the activities of our agronomists and economists related to this research and focuses on the contribution of OFR to technology generation.

Rationale for a Systems Perspective

In the early 1970s, CIMMYT sponsored a series of studies to examine differences in farmers' adoption patterns for high-yielding varieties and improved management practices. These studies showed quite clearly that new technologies are adopted only when they fit farmers' circumstances—agroecological and socioeconomic. Thus it was crucial to ensure that recommendations made were consistent with farmers' circumstances.

Four elements, we found, are critical to an efficient research strategy.

1. Careful identification of the farmers for whom recommendations-—the so-called recommendation domains—apply.
2. Recognition of how interactions—immediate and long-term, biological and economic—shape farmers' response to a technology in very complex and variable environments.
3. Involvement of both biological and social scientists in the research process from the beginning as the most efficient way of addressing system interactions.
4. Conduct of much of the research on-farm with farmer participation.

These four elements are the basis of CIMMYT's approach to on-farm research.

Strategy for OFR

In developing a strategy for OFR three important elements were recognized.

1. CIMMYT sees technology development as the responsibility of the national programs; hence methods used must be consistent with national program resources.
2. Because planners often attach high discount rates on returns to investment in agricultural research in developing countries, immediate improvements in technology are strongly preferred to longer-run increases, even where the latter might give higher ultimate returns.
3. Farmers adopt only a few changes at a time in a stepwise manner rather than several changes in a package.

Against this background, CIMMYT has chosen to concentrate OFR on one (e.g., wheat) or two (e.g., maize/bean intercrop) enterprises at a time—while recognizing competitive and complementary relationships with other activities—and on only a few high-priority components in these crops.

These characteristics make our OFR cost-effective by providing procedures within reach of national program resources and by emphasizing short-run results, compatible with farmer adoption patterns.

Well focused diagnosis and planning also contribute to cost effectiveness. To eliminate irrelevant solutions early on, possible solutions are screened for compatibility with the circumstances of representative farmers.

OFR is closely linked to other research activities of the national research systems, which CIMMYT seeks to strengthen. Collaboration with national scientists through OFR helps set longer-term priorities for experiment station research. Extension personnel are also involved throughout the OFR process.

The advantage of our OFR strategy is that, working closely as it does with national scientists and farmers, it formulates improvements that are likely to be widely used in the short term. Its major disadvantage is that its focus, being narrow, might miss complex improvements that require simultaneous changes in several parts of the system and, perhaps, potentially very profitable in the long term.

Methods for On-farm Research

CIMMYT's on-farm research methods are specifically designed for the limited resources of national programs. Flexible enough to be adapted to a range of environments, they are, however, formulated to give firm guidelines to scientists inexperienced in OFR. And, although devised for maize and wheat, they can also be applied to a variety of crops. Figure 3 shows the five stages in our OFR sequence.

1. **Diagnosis** includes: (a) a review of secondary data; (b) an informal survey, by biological and social scientists, who visit farmers' fields and talk with farmers, merchants, and others; and (c) a formal survey. The informal survey is the keystone of the diagnostic stage and is indispensable. Diagnosis should continue throughout the research process.

2. **Planning** the content and design of on-farm experiments, the number and characteristics of the fields to be planted, and the type of data required. This planning is based on results of the diagnostic stage and previous years' experiments.

3. **Experimentation,** the central part of OFR, wherein we look at a small number of technological components. Experimental design may be grouped broadly into experiments that seek to (a) explore and define problems; (b) test solutions to defined problems; and (c) verify workable solutions.

4. **Analysis** of on-farm experiments—a review of agronomic responses, statistical analysis of the results, and finally an economic analysis. Formal assessment is complemented by continually reviewing proposed solutions to see how compatible they are with the farming system, especially by seeking farmers' opinions and observations.

5. Development of appropriate **recommendations** in the context of scarce resources, is the goal of on-farm research. We recognize that the recommendations—whether specific or general—will be adapted by the farmers to suit their own conditions.

6. **Follow-up** on farmers' experience with new recommendations, an essential part of on-farm research. Extension workers are involved, from the start, in the research process and become familiar with the technology as it develops.

Institutionalization of OFR

The major thrust of CIMMYT's OFR is to develop and spread a set of research methods for use as guidelines by national programs. These programs are throughout encouraged to refine and adapt our procedures to fit their needs and to develop networks among countries to share experience. A growing number of scientists are now using these OFR methods in over 20 countries.

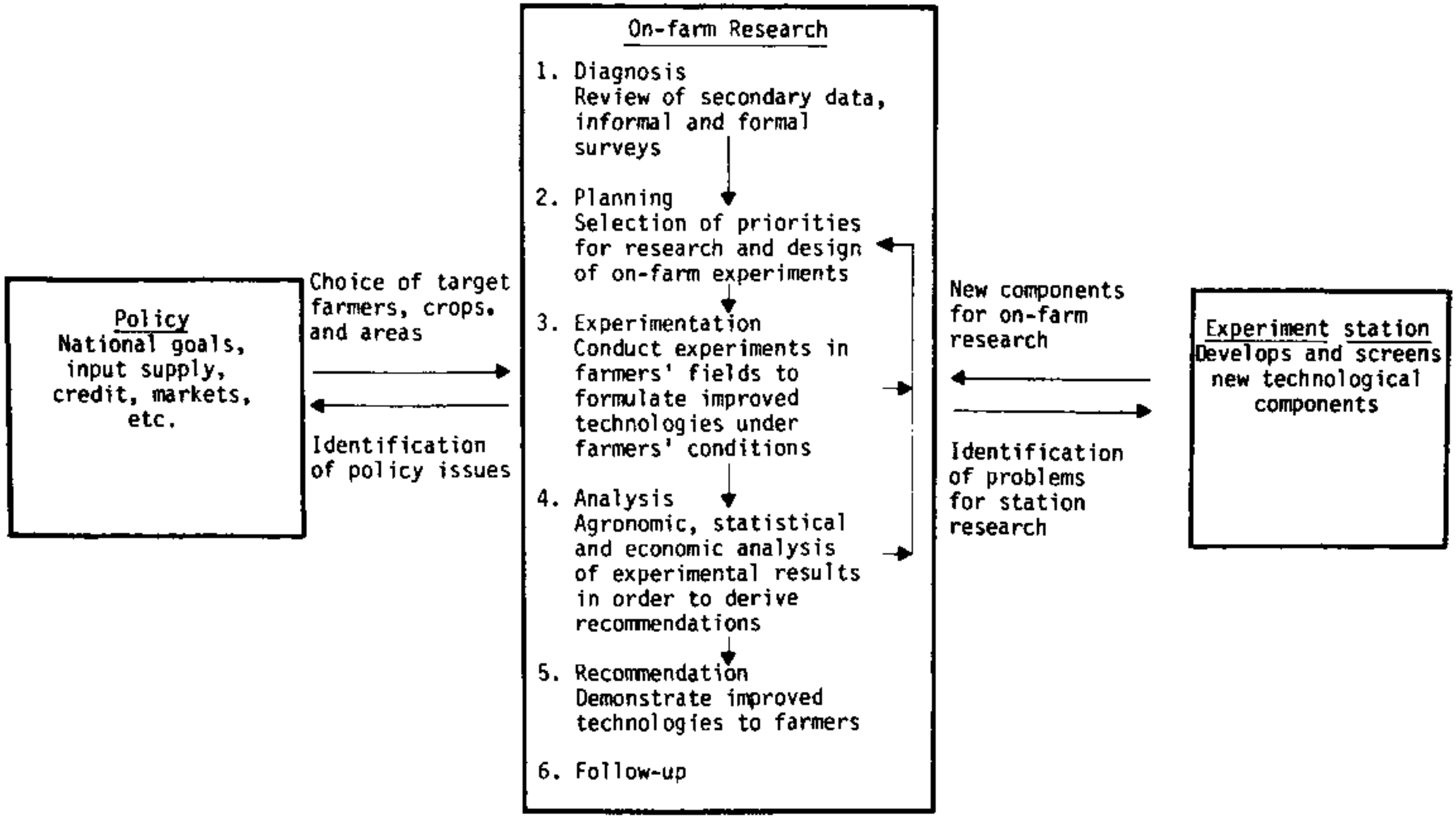


Figure 3. Stages of on-farm research at CIMMYT.

CIMMYT fully recognizes that other IARCs may design and participate in very different kinds of systems-based research. Where these involve training national personnel, the IARCs must carefully coordinate their efforts to avoid sending confusing or contradictory messages to the very national programs they seek to strengthen.

In addition, it is evident that such research cannot be carried out in an institutional vacuum. Research philosophies and methods have implications for the organization and management of research institutions. Whether OFR should be organized on a commodity basis or on a regional basis; whether it should be carried out by a separate program or a liaison mechanism among existing programs and departments; whether it demands full-time practitioners or can be integrated into current research activities; what mechanisms will ensure interdisciplinary cooperation in research and involve extension institutions in the work—are all issues crucial to the success of the approach in a national setting. No one of the IARCs has the expertise to completely resolve these questions; however, discussions must be opened which involve IARCs and, most importantly, national agricultural research systems in order to better respond to the crucial problem of organizing and managing systems-based research.

Generating Appropriate Technologies with Small Farmers : the CIP Approach

R.E. Rhoades, M.J. Potts, R.H. Booth, D.E. Horton, and M. Upadhya[1]

Introduction

The International Potato Center (CIP) began as early as the mid-1970s to build strategies linking potato science research with national program researchers, farmers, consumers, and other clients. CIP has deliberately not established a separate farming systems research program; however, the Center is strongly involved in on-farm research within a "food systems" (rather than "farming systems") framework. This research has the following aims. (1) To generate research results for the needs of a varied clientele—from farmers, farm households, small-scale gardeners, consumers, traders, and others to national policymakers. (2) To streamline, in a cost-effective way, CIP's own basic component experimental research program. (3) To provide a practical focal point for production and postharvest training in national programs and regional networks. (4) To generate basic information for a broader socioeconomic and technical understanding of the potato in the food systems of developing countries.

1. Centro International de la Papa, Lima, Peru.

CIP's Organization of Research

CIP is organized around source research in Peru and regional research and training in eight world regions. It has also encouraged individual countries to pool resources to solve common problems over regional networks.

CIP has 10 major (interdisciplinary) research thrusts, ranging from collection and maintenance of the world potato collection to the study of the potato in food systems. The last integrates the biological and social sciences, recognizing interdependence in the food system and how different stages affect each other (seed procurement, production, storage, processing, etc.), in terms of technology use. The focus, however, remains on potatoes and producers.

Background of CIP's Farmer-back-to-Farmer Strategy

The potato crop is grown under diverse, often marginal, ecological (and social) conditions, CIP's philosophy and methods were evolved chiefly in the homeland of the potato, the Peruvian Andes. In the mid-1970s, in an attempt to get researchers on the farm, CIP began an experimental exercise in the Mantaro Valley in Peru (3000 m asl), using three teams with different goals and approaches.

1. A potato-production constraints team developed and tested procedures for identifying such constraints and for testing known technologies in farmers' fields.
2. A seed-systems team sought reasons for the failure of seed-potato certification programs in developing countries and ways of improving and increasing certified seed use.
3. A postharvest team sought to develop simple postharvest technologies that would build on traditional practices. The inclusion of an anthropologist on the team gave it a new direction and its work resulted in the creation of CIP's farmer-back-to-farmer strategy.

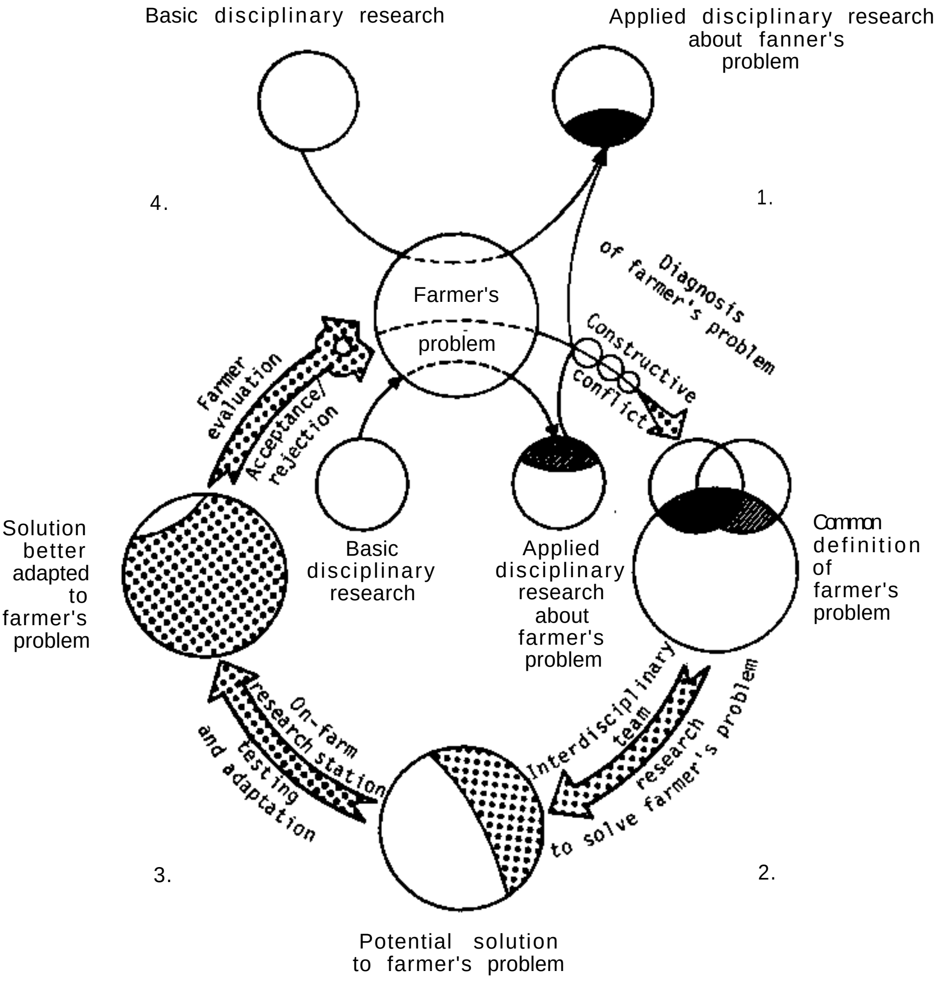
Systematically comparing farmers' and scientists' practices and blending the experience of all three teams has led to CIP's present approach.

The farmer-back-to-farmer model

CIP's model of technology generation (see Fig. 4, based on work by Rhoades and Booth) assumes that effective applied agricultural research and transfer *begins* and *ends* with the farmers; i.e., that research must come full circle from proper identification of the problem to acceptance or rejection of the solution.

Understanding and learning

The understanding and learning stage includes farmers, social scientists, and biological scientists, each group supplying its own expertise and perspective to the common framework for action. The farmer in this setup is an expert, working as an equal with researchers, based on his long-term experience with the land, climate, and socioeconomic conditions. Building upon, rather than wholly replacing, traditional practices is our route to successful problem-solving.



Activities	Goals
1. Diagnosis of farmer's problem	A. Common definition of problem by farmers and scientists
2. Interdisciplinary team research to solve farmer's problem	B. Identify and develop a potential solution to the problem
3. On-farm testing and adaptation	C. Better adapt the proposed solution to farmer's conditions
4. Farmer evaluation	D. Understanding farmer acceptance or rejection of solution

Figure 4. Farmer-back-to-farmer—a model for generating acceptable technology.

Seeking solutions

Solutions are not a mere matter of transferring the right ones from a vast existing technology pool. A constant on-the-spot exchange is needed between those who test hypotheses on the research station and those who will use the resulting technology. This interchange should continue throughout the selection stage, and compromise, reversal, or even termination of projects may be needed and are best effected at this stage.

Testing and adapting potential solutions

The goal at this stage is to fit the selected technology to local conditions, with the farmer as the adviser to the team, which should include extension workers. The technology should pass tests for technical, economic, and sociocultural suitability, which may show the need to modify not only the technology but also testing methods. For instance, CIP's costly station-built seed store turned out to be inappropriate, and designers had to devise less expensive designs. It is important during on-farm testing to compare new solutions with traditional methods. Adaptive testing may require several recyclings to reach worthwhile solutions. It is also possible that the traditional method cannot be improved.

CIP encourages farmers to participate as much as possible in the design of trials, though this may not always be easy in areas where farmers (at least outwardly) defer to academic or urban-based researchers. Hence scientists need to spend more time in the field to build a working rapport with farmers.

Farmer evaluation: the crucial stage

In agricultural development, sadly, follow-up of an introduced technology is rare. By contrast, in the farmer-back-to-farmer model, follow-up is the crucial link. Actual use of the technology by the farmer is the final criterion of its appropriateness and data must be collected on its reception by farmers. A return to the adapting stage may be needed; in extreme instances, if the farmers reject it outright, the whole research circle may have to be repeated to determine why.

In the final stage, farmers independently evaluate and use the technology under their own conditions, resources, and management. At this stage scientists must understand not only how acceptable it is but exactly how farmers continue to adapt it. Further, researchers must also monitor the wider impact of the technology to ensure that it does not affect the well-being either of the farmers or of society at large.

On-farm Research Methods

By the early 1980s, CIP's experience in the Andes and other regions had shown that complex packages of technology were usually not feasible, understandable, or appropriate to the LDC farmers' local conditions. Simple changes that build on farmer's knowledge and traditional practices appeared more viable options. At the other end of the spectrum, CIP came to grips with the realities of national program constraints—of funding, resources, and trained manpower—that restrict interdisciplinary research. Thus CIP has developed a flexible approach rather than a rigid sequence of procedures. For instance, diagnosis may begin with simple experiments to define the problem; a formal questionnaire may be more appropriate later to monitor the acceptance or impact of a technology.

This eclectic approach with farmer-scientist participation evolved largely from our experience in Andean communities, which often made it a condition that researchers contribute to their farming from the beginning, with training, experiments, pamphlets, field days, etc.

Application of the farmer-back-to-farmer model

Rustic seed stores. After 25 years of failure by development agencies to introduce free-standing consumer potato stores, the CIP postharvest team discovered that farmers were chiefly concerned with the storage of improved-variety seed to reduce sprouting. In consultation with farmers, the team developed a prototype model. More than 3000 farmers adopted it, but 80% of them used not the prototype design but existing structures modified for diffused-light storage. This technology is now entirely with regional and national programs.

Seed schemes. Seed schemes based on successful industrial country models often fail in subsistence farming conditions, underscoring the need to understand how farmers perceive the seed program. For example, in Peru, CIP found that variety Mariva, which was central to the multiplication program, was not popular with many farmers. Accordingly, other varieties that met farmers' needs were included. We also found that only 15% of seed used by small producers is bought from large seed growers. New program strategies were evolved to release clean seed through informal channels.

Such farmer-back-to-farmer organization of research activities around a circular flow of information between farm and research helps guarantee relevance.

The tropical potato. In much of the lowland tropics the potato is a new crop but may be grown with profit to farmer and community with the right program strategy.

In the Philippines, for instance, potatoes—grown only in the highlands with high labor and transport costs—are a high-priced commodity. Expansion of highland potato cropping might further upset a fragile ecological balance. But consumer potato cropping could be done in the lowlands, after rice, during the slack winter season. Highland growers could concentrate on seed tuber production, which would maintain their incomes. Lowland growers could add a new cash crop, and expanded production would bring down the prices of this nutritious and filling food. The Southeast Asian Program for Potato Research and Development (SAPRAD), adopting the farmer-back-to-farmer model, has evolved a program jointly with farmers, researchers, and extension workers. Highland farmers and technicians instructed lowland growers in planting and growing the crop; thereafter, the lowland farmers grew it at their own risk but with technical backstopping by SAPRAD and national programs. The best results gave returns of more than 250% over investment.

Thus a new production system and crop have been introduced and experimentally adapted quickly and efficiently.

Central Africa—Example of CIP's Country Program Approach

In Burundi and Rwanda, where food shortages are pressing, the national governments consider the potato a high-potential crop. CIP, at their invitation, has adopted an interdisciplinary approach involving farmers, research scientists, and university staff, to rapidly diagnose common problems. Client participation is thus more important than institutionalization of procedures.

Technology evaluation

As with data collection, procedures used for evaluating technology are simple and flexible, making full use of the practical experience and innovative nature of farmers. However, the importance of the research station is equally recognized, especially in reducing risk to farmers. Germplasm evaluation at the initial stages or techniques for dormancy-breaking, for instance, is done at station level, through simulating farm conditions of soil fertility, insecticide use, etc.

On-farm trials are kept simple, with one, or at most two, variables, and with frequent discussions among all groups concerned.

Extension

While extension is a national program responsibility, wide diffusion takes place readily, because of the various organizations involved from the very beginning in the research process, and because CIP includes the technological principles in all training courses at all levels.

Conclusion

CIP studies the potato and the people whose lives it touches through the food chain, at each stage and between interdependent stages, placing research within the broader context of the food system.

Work teams are small, procedures flexible, and research design simple. CIP is strongly convinced that the key to success is a close—and equal—collaboration between researchers and clients. On-farm research sharply focuses on components but is fully sensitive to the food system (including other crops) within which the crop exists.

Review (2)

M.H. Arnold[1]

I found the papers from CIMMYT and CIP very interesting. Here we have two Centers starting from somewhat different premises but arriving at remarkably similar operational procedures.

This may be an oversimplification, but CIMMYT seems to have started its OFR from a farming systems approach and narrowed it down to something more easily translated into action. CIP appears to have started with a commodity approach and broadened it to include the perceptions of farming systems.

CIMMYT stresses that, because farmers tend to make few changes at one time, it concentrates in its OFR on only one enterprise at a time, but also recognizes the complementary relationships and interactions with other enterprises.

CIP says essentially the same thing in a different way. The focus is on potatoes (the commodity) and primarily, but not exclusively, on the producer. But the commodity focus is broadened to include the food system of which the potato forms a part.

CIMMYT says that a narrowing of focus raises the chances of formulating improvements that will be widely adopted, but notes the disadvantage that potentially valuable improvements based on multiple changes might be missed.

CIP comments that holism (a major premise of FSR) has its positive side but it also has its operational problems. The emphasis in CIP's case is therefore to focus on the most important activities and then investigate the interactions by placing the changes in progressively wider contexts.

The two approaches, therefore, have a great deal of common ground.

Both also stress the need to eliminate irrelevant solutions early in the process, and following that the general methodologies adopted are essentially similar.

CIMMYT uses a five-stage approach in which the whole process is iterative. CIP's farmer-back-to-farmer model is also obviously iterative but only four formal stages are recognized. Looking at the detail, however, the differences do not appear to be substantive and I would have thought that the two approaches could easily be thought of as one.

Regarding national programs, CIMMYT stresses the role of OFR in strengthening national research systems and regards *them* as having the primary responsibility for generating improved technology. The importance of involving national scientists and extension workers in OFR is also stressed.

CIP makes similar points but has gone further in some of its programs, notably in Rwanda and Burundi. When national programs have been in need of intensive support, CIP has established country programs in each of which a CIP scientist is based to work full-time with national scientists. This strategy contrasts with some of the views expressed already at this workshop and is bound to generate further discussion in the CGIAR. My own view is that there are some circumstances, i.e.,

1. Plant Breeding Institute, Trumpington, Cambridge, UK.

where you have very weak national programs, in which it is entirely justified. One point made by CIP, about flexibility, perhaps requires further thought. "National scientists" according to CIP, "should not be trained in or feel compelled to follow a rigid set of procedures on how to do on-farm research." Although the idea of flexibility is readily acceptable, one wonders how flexible—when flexibility results in major differences that militate against a common approach across Centers for training purposes.

Reference was made at the beginning of this workshop to some criticisms in recent years that have been leveled at FSR. This was epitomized during the second review of the CGI AR system when one donor exclaimed to the study team: "Why is it that when we now work on farmers' fields we have to call it FSR?" (the implication being that this was somewhat esoteric). "Why," he added "can we not get back to some honest-to-goodness old-fashioned production research on farmers' fields?"

I suggest that what we are seeing in these two papers is what has evolved from old-fashioned production research. The primary focus is still on the producer and mainly on the single enterprise or commodity, but it also incorporates or takes into account other enterprises and other considerations that might be neglected if it relied solely on inputs from a bunch of scientists, be they natural scientists or social scientists. I conclude, therefore, that for both CIMMYT and CIP the proper taxonomic classification (in the Simmonds mode) should be OFRWFP, i.e., on-farm research, with farmer participation!

Farming Systems Research at ILCA

G. Gryseels, J. McIntire, and F.M. Anderson[1]

Introduction

The International Livestock Center for Africa (ILCA) was established in 1974 to serve as a multidisciplinary institution for research into livestock production systems in sub-Saharan Africa, to train national scientists in a systems approach to such research, and to be a documentation center—with the overall aim of improving food production through better integration of crop- and animal-based farming systems.

In the early years, the emphasis was on detailed base-line studies and the transfer of existing technology from elsewhere; field teams therefore contained a major socioeconomic component. But as existing modern technology was found to give little advantage over traditional methods under prevailing economic and ecological conditions,

1. International Livestock Center for Africa, Addis Ababa, Ethiopia.

the emphasis has increasingly shifted to component research—for instance forage legume agronomy and animal nutrition—to develop new technology.

Today ILCA's research program has decentralized field research units in major ecological zones of sub-Saharan Africa, complemented by central component research units at ILCA headquarters. Networks provide a bridge between the ILCA and the national research programs.

Objectives

ILCA's objectives in systems research are to: (1) diagnose constraints to increased animal production, (2) develop prototype technologies under farm conditions, (3) develop research methodologies, (4) monitor technology adoption, and (5) help build national capability to do systems research.

To these ends, ILCA operates field teams to test the systems approach as well as specific techniques, provides direct staff support to national research institutes, develops models to appraise rapidly the effects of interventions, and prepares training manuals and participates in formal training courses on farming systems.

ILCA's Approach

ILCA's approach has always emphasized multidisciplinary systems research on-farm rather than on-station. Development of methodology is stressed because livestock research is sometimes more complex than crops research: multiple productivity parameters are involved, individual management factors can be of major importance, daily rather than seasonal inputs are required, and extended time periods are needed for experiments.

The three principal livestock production systems in sub-Saharan Africa are the smallholder, the agropastoral, and the pastoral. The smallholder systems—with their smaller grazing area and greater crop-livestock integration—offer more technological alternatives for increased production. The pastoral systems, highly mobile and nomadic, with no fixed land base and extensive grazing areas, are most difficult to research and to improve. The agropastoral systems are a transition between these two systems.

ILCA's farming systems research follows four stages. (1) Diagnosis, with short-and long-term surveys of existing systems and the ecological, socioeconomic, and technological context. (2) Design, in which potential improvements are designed and their likely impact assessed through simulation and cost-benefit models. (3) Testing of improvements in trials by producers. (4) Extension, in which proven technologies are given to national extension services, adoption is closely monitored, and redesign and retesting are undertaken as needed.

Present Status

ILCA programs presently operate in smallholder systems (the Ethiopian highlands and the Nigerian humid zone in Ibadan); in pastoral systems (Kenya and Ethiopia); in the agropastoral subhumid zone around Kaduna, Nigeria; and the arid and semi-arid zones of West Africa.

Smallholder farming

In the Ethiopian highlands, the aim is to improve overall production through increased efficiency of the livestock component. Station research focuses on soil fertility, forage production, draft animal use, and Vertisols utilization. Potentially productive technology—such as the use of a single ox instead of the traditional pair—is offered early to farmers and adoption continuously monitored.

A dairy husbandry package increased farmers' income in the medium altitude area around Debre Zeit, and other constraints—such as high calf mortality, seasonal labor shortages, and forage crops cultivation—are now being addressed by component research.

Humid zones

In the mixed-farming forest zones, a vaccination program for small ruminants reduced adult goat mortality from PPR *(peste de petits rominants)* by 50%. Work is now concentrating on feed sources for the resulting larger flocks; an alley-cropping system worked out by IITA was adapted by ILCA, was given a short field trial, and is now in long-term station trials.

This approach of conducting research with farmers to identify, and on-station to quantify, relevant parameters, was used because the IITA model had no animal component.

Subhumid zones

The subhumid zones, with a rainfall of 1000 to 1500 mm per annum, offer good potential for crops and livestock. Inadequate nutrition was identified as the chief constraint to livestock production, and a program of nutrition research established in collaboration with the National Animal Production Research Institute of Nigeria. Much of the current work is to evaluate the economics of the proposed interventions.

Pastoral areas of eastern Africa

Interdisciplinary base-line studies were begun in the 1970s. In Kenya, using the household as a sampling unit, data were collected on intra- and interhousehold parameters affecting production; for instance, division of resources and responsibilities within the family, or control and maintenance of water and grazing. Aerial surveys were used to estimate domestic and wildlife biomass and mobility patterns.

In the Ethiopian rangelands—in conjunction with the Government's rangelands Development Project—ILCA's research thrust was to measure the impact of earlier interventions, especially of the rainfed water ponds set up to improve distribution of water points, and programs on disease control and vaccination, etc.

A much larger area than in Kenya has been studied; satellite imagery was used to subdivide it into ecological units, which were then surveyed aerially.

Arid and semi-arid zones of West Africa

These zones differ markedly from other mandate areas. Both annual cropping and pastoralism are important. Dry-season nutritional stress is severe, outputs low, and risks high. Poor animal nutrition and poor herd and pasture management were diagnosed as the chief constraints to animal production. Research has identified crops such as cowpea and forage legumes for cultivation systems. For transhumant and semisedentary systems, pasture and flock management techniques have been identified to increase productivity.

Modeling

Modeling is used principally for economic evaluation of technologies—of components to assess profitability of interventions and of technology design, to suggest technical solutions. A herd simulation model of supplemental feeding to dairy cattle (developed by Texas A&M University) was adapted by ILCA for use in Botswana, Mali, and Nigeria. Future modeling will simulate pastoral systems and test farming components in areas of high population density where annual cropping dominates.

Fulfillment of Objectives

ILCA has successfully met four of its five objectives. Constraints to animal production have been diagnosed in all major systems. Research methodology appropriate to ILCA's mandate areas has been adapted or developed, and techniques such as aerial surveys used with reasonable success. Technology adoption is being successfully monitored in the Ethiopian highlands. ILCA's close collaboration with national programs on Ethiopia, Nigeria, Mali, and Zimbabwe has helped build national capacity to do systems research, especially on smallholder systems. Development of prototype technology under farm conditons, however, has been less successful, and smallholders have yet to adopt proven technology widely. Progress has been most difficult in pastoral systems.

As an international center, ILCA has a comparative advantage over individual national programs in such areas as information processing and in being able to operate field programs on an ecological basis rather than along national boundaries.

Cost-benefit analyses done so far have shown the following to be profitable: (1) in the Ethiopian highlands, a crossbred cow package; (2) in the humid zone, a small ruminant health package; and (3) in the subhumid zones, fodder banks.

Outlook

ILCA continues to give high priority to strengthening national institutions. In that role, the Center has a comparative advantage in such areas as germplasm collection, data gathering and analysis, survey techniques, training, and network development. ILCA envisages that its systems research will continue to have its own field teams for base-line research and to test technology components developed at headquarters. Organizing training for national programs in techniques for improved livestock production in sub-Saharan Africa will be a major activity.

Farming Systems Research and the International Fertilizer Development Center

J.A. Ashby and P.L.G. Vlek[1]

The mandate of the International Fertilizer Development Center (IFDC) is to assist developing countries of the tropics and the subtropics to achieve increased use and efficiency of fertilizers to improve food production. IFDCs approach to farming systems is broadly similar to that used by CGIAR commodity-oriented research programs.

Research covers three broad areas. (1) Integrated fertilizer management, to identify the proper role of fertilizer inputs for major cropping or farming systems. (2) Efficiency of fertilizers in various agroecological zones. (3) Farm-level constraints to fertilizer use. With research and outreach programs specialized in all aspects of fertilizer technology, IFDC has a comparative advantage in developing and testing new fertilizer components for farming systems in the tropics.

Research Methodology

Concepts and methods used by IFDC to address fertilizer-related problems are as follows.

1. Diagnostic research, consisting of (a) the rapid diagnostic survey, with informal interviews and formal questionnaires; (b) the rapid key-informant survey, with early emphasis on interpreting farmers' objectives, needs, and problems related to agricultural innovation; and (c) participatory research, discussing with innovative farmers the technical components to be tested to evolve **a** "farmer design" for on-farm trials.

2. Technology development for farm conditions, identifying appropriate fertilizer technology for crop and soil conditions of various ecological zones. On-station research in such projects evolves from feedback received from on-farm experiments.

1. International Fertilizer Development Center, Muscle Shoals, AL, USA.

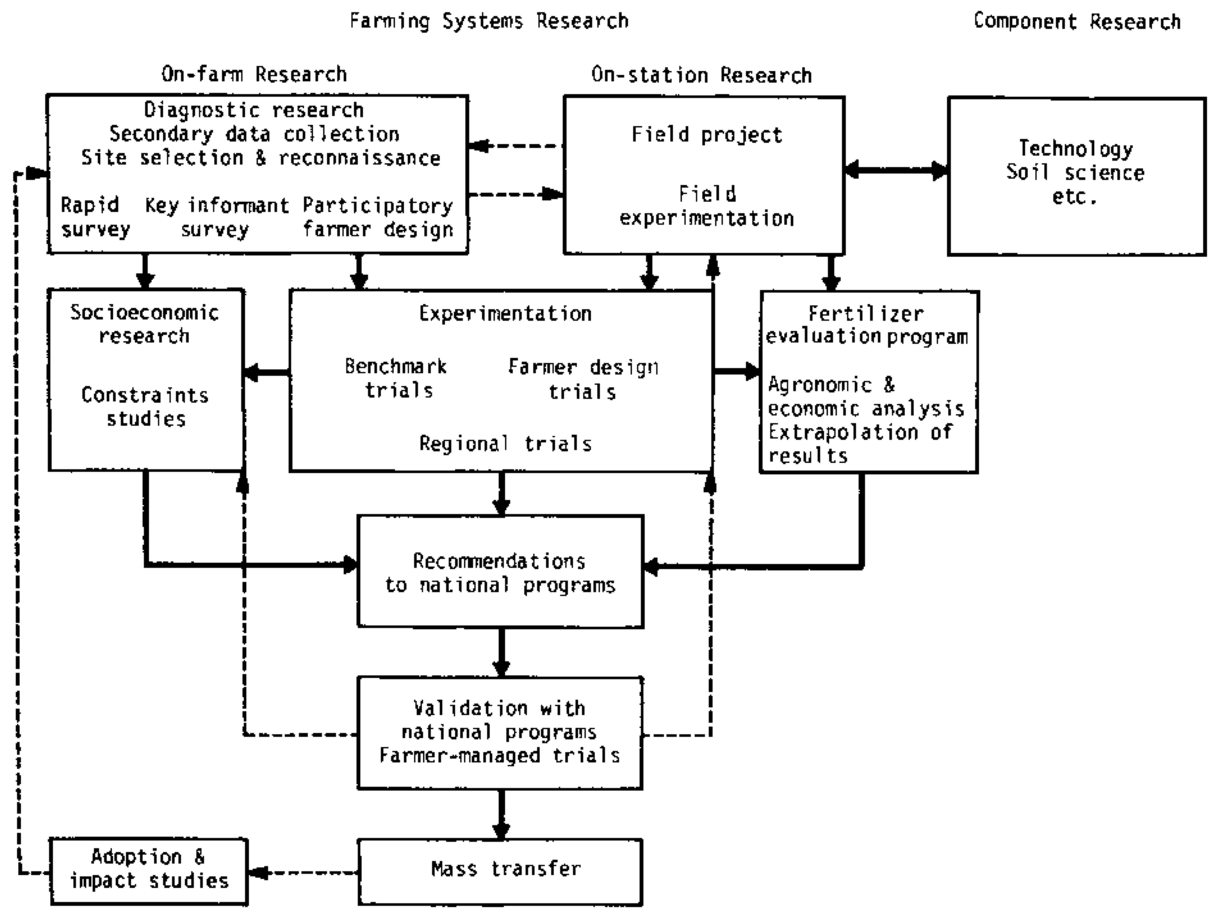


Figure 5. Flowchart showing alternative models for farmer participation in on-farm testing of fertilizer technology. Broken lines indicate feedback from farmers to researchers.

On-farm research may also include experimentation to verify plant-soil-nutrient relationships under farm conditions. Factors that influence farmers' decisions, such as land tenure, land markets, soil degradation, etc., are analyzed by socioeconomic research at farm level. Benchmark experiments, utilizing a large number of treatments and replications, are managed by researchers to screen new fertilizer technologies. Selected treatments from the benchmark experiments are tested in regional trials in farmers' fields. Farmer management is introduced at an early stage of on-farm testing in trials utilizing a "farmer design", called farmer design trials. This approach is shown in Figure 5.

Validation of technical recommendations is done by national programs, with support from IFDC's Outreach Division. IFDC's Fertilizer Evaluation Program and Information System monitors the adoption and impact of fertilizer use, including policy implications of expanding demand for fertilizers.

Linkages with National Programs

IFDC's farming systems projects are conducted in collaboration with national institutions, usually those with primary responsibility for soils research and fertilizer recommendations, as, for instance, in Bangladesh and Indonesia. The IFDC/CIAT Phosphorus Project works with several Latin American soils research programs. Building networks with national program researchers who will ultimately undertake the main role in site-specific recommendations is an important feature of farming systems research.

Farming systems research at IFDC is not a separate program. Rather it is a problem-solving approach incorporated into a variety of projects to which many staff members contribute, either directly in the field or indirectly via headquarters research. A salient advantage of this organizational model is that it encourages the flow of information between on-station and on-farm research efforts. It also creates a broad base for interaction between Centers and between researchers of various disciplines within IFDC.

Review (3)

J.G. Ryan[1]

Farming Systems Research at ILCA

The paper from ILCA exhibited refreshing candor in assessing reasons for success/ failure and identifying comparative advantage. I wish there were more IARC papers

1. Australian Centre for International Agricultural Research, Canberra City, Australia.

like this—ICRISAT attempted to and also CIP—more papers could have "shown and confessed" as opposed to "show and tell."

A feature of ILCA's FSAR is that it has a production or ecological systems orientation.

Does FSR have most potential in sedentary systems? This may be true of all research, not just FSR, due to the harshness of the environment in pastoral/ nomadic systems, which are a response to it. Additionally, it may be due to separation of ownership and management of land, labor, and capital in these environments. Holism refers to the problems of entrepreneurs who have responsibility for manipulating scarce resources over which they have managerial/ ownership authority. These characteristics are not usually a feature of transhumant/pastoral/nomadic systems: This could explain ILCA's modicum of success in research on smallholders but its lack of progress in pastoral systems. There may be a need for agricultural systems research in pastoral environments, not just farming systems research.

Is FSR best suited to unfavorable environments, as CIMMYT and David Norman suggest? ILCA's experience suggests it may not be.

Is it appropriate for ILCA to continue as an adapter of existing technology? Should it primarily synthesize and extend information rather than conduct research? Or should it reinforce recent trends to strengthen its component research on items such as forage legume agronomy and animal nutrition? The latter mode will presumably imply a different style in ILCA's FSR approach in future.

OFR began at an early stage at ILCA. In retrospect was this the correct approach? Or, in view of the recent strengthening of component research, should it have been introduced later or at a reduced intensity and with a different style?

ILCA is heavily involved in development programs, but there does not seem to be a clear rationale for this involvement. Was it opportunistic?

ILCA has made extensive use of models to assist in technology design and evaluation. What use was made of agroclimatic modeling to characterize the environments in which ILCA is working?

No uniform FSR approach is evident across the various ecological zones. Each seems to have its own unique emphasis and employs a range of strategies usually regarded as a feature of FSR approaches. Is this appropriate? Or does experience suggest there are certain minimum or uniform FSR elements which are required regardless of the agroecological system being studied? Is there a standard disciplinary mix which is appropriate?

FSR and the International Fertilizer Development Center

A feature of FSR at IFDC is that it is a philosophy and is not formally structured. Farmers are involved at an early stage of their on-farm research (OFR) activities—virtually at the design stage. Diagnostic surveys are conducted at the same time as the farmer design trials. It seems that diagnostic trials are not a component of OFR at this stage.

Policy research is likely to be an important aspect of the portfolio of a Center whose mandate is an input such as fertilizer. The paper mentioned that policy research is a component of FSR but there was little discussion of the type of research that has been conducted.

There seems to be an effective OSR/OFR link—at least on paper. It is stated that IFDC works closely with national agricultural research systems. However, this seems frequently to involve location of staff at other IARCs rather than directly with NARSs. The rationale for this model is not clear from the paper.

This raises the question of the role and purpose of FSR at IFDC—and indeed the other IARCs. To what extent is FSR intended to provide guidance and direction at the technology design stage for the IARC, and to what extent is it to help fine-tune technology options developed from whatever source, be they the NARSs and/or IARCs? My concern is that often FSR activities of IARCs place undue emphasis on promotion of their particular "technology package."

It is not clear to what extent scientists at IFDC headquarters are involved in OFR activities and, in particular, how information from OFR is incorporated into the development of new processes, compounds, and techniques in fertilizer production.

Who are the clients for IFDC's research? One would expect that fertilizer manufacturers in developing countries would be one of IFDC's primary clients. The paper did not discuss this part of the linkage or their role in OSR and OFR.

Chairman's Summary

P.R.N. Chigaru[1]

FSR activities in all the seven Centers covered in this session have major similarities in their objectives as well as in implementing strategies. There are, however, some differences in emphasis. The methodologies of IRRI, CIAT, CIMMYT, CIP, and ILCA are somewhat similar in that they do emphasize the need for refining FSR approaches as well as assisting NARSs in carrying out FSR. IITA and IFDC, on the other hand, did not highlight this aspect formally in their papers.

In describing the experience they gained with FSR, ILCA was the only Center prepared to admit to both successes and failures and in identifying its comparative advantage as an international center. CIP also gave more of an insight into some of the problems the program has faced in the field, such as with small NARSs as typified by Rwanda.

With respect to implementation activities, all Centers appear to conduct base-data analysis and are agreed that FSR is best incorporated through a research continuance that includes on-station research supported by strong on-farm research programs. The emphasis on on-farm research varies between Centers, however, and CIAT, CIM-

1. Research and Support Services Department, Ministry of Agriculture, Harare, Zimbabwe.

MYT, CIP, and IRRI place major emphasis on OFR through NARSs. ILCA conducts its own OFR at its field sites, with limited participation by NARS; IITA has very little OFR, which it tests at its headquarters. IFDC appears to work more directly with other I ARCs than with NARSs, although OFR activities are described as an important element of IFDCs research programs. In the case of IITA, which has an area-based and a commodity/ input-based mandate on FSR, it is recognized that IITA is engaged mainly in attempting to achieve major alterations to the existing farming systems in the humid tropics of Africa with the objectives of increasing food production on a sustainable basis.

Most of the differences noted above derive from the diversity of the mandates of the Centers and are to be expected. During the discussion, however, there was a feeling that Centers should explore opportunities for harmonizing their activities. There is a need for them to identify some key concepts or features of FSR that can justify a common label for their programs. In this respect IARCs should collaborate more closely and should not desist from criticizing each other's methods. They should seek joint approaches to NARSs and conduct joint training programs.

With respect to their interaction with NARSs, it was not clear from the presentation how IARCs deal with NARSs of different size and institutional development and the level at which they pitch their training activities. Perhaps this is an area in which ISNAR could assist the other IARCs since they have, over the past 5 years, reviewed NARSs of different sizes and complexity. On the question of training, it was felt that all Centers should develop manuals and attempt to achieve some harmony in such manuals so that these can be used not only by the IARCs themselves but also by NARSs during in-country workshops.

One important point made during the discussion was the question of land tenure systems and how these affect FSR. It was suggested that, as a general rule, Centers should not become involved with issues of a national/political nature, since even NARSs also always try to work under given sociopolitical conditions, irrespective of whether or not this reduces their effectiveness.

Session 4

Evaluations and Policy Implications

Chairman: J.L. Dillon
Rapporteurs: R. Lal, IITA/T.S. Walker, ICRISAT
Reviewer: CO. Andrew

Organization and Managerial Implications of a Farming Systems Approach for National Agricultural Programs

W.A. Stoop[1]

Introduction

Organization and management of agricultural research in developing countries is a major concern of the International Service for National Agricultural Research (ISNAR). With the realization that much agricultural research is conducted on experiment stations, isolated from and often irrelevant to farmers' field conditions, increasing emphasis is being placed on farming systems research. However, a lack of knowhow and managerial and organizational difficulties often hamper such research projects. This paper discusses these problems and outlines a farming systems perspective (FSP) on research that could profitably be taken by national programs.

Relevance of FSP in Setting Research Priorities

A major contribution of FSP is its holistic approach. It considers not only the technical and biological but also the socioeconomic and institutional aspects of agricultural production. FSP integrates increasingly specialized research with farmers' requirements to set research priorities; thus its strategies will need to be flexible enough to respond to the range of farming systems it must consider.

Technologies that fostered the dramatic "green revolution" in irrigated wheat and rice do not apply under the highly variable and complex conditions of rainfed farming, which require far more site-specific identification of constraints.

Given the vast areas under rainfed farming, the shortage of trained research personnel (see Table 1), and the increasing numbers of small farmers forced to cultivate marginal and degraded lands, international organizations could best focus their research by (1) limiting on-farm research to a few contrasting agroecological situations while closely collaborating with national networks of on-farm test sites; (2) emphasizing not only yield and biological potential but also other production criteria that influence technology adoption; and (3) complementing efforts to increase productivity with research to increase sustainability at low input levels.

Such research emphases would increase the utility of IARC research for different categories of clients.

1. International Service for National Agricultural Research, The Hague, The Netherlands.

Table 1. Comparison of numbers of agricultural research scientists with total population and total surface of arable land for some selected developing countries.

Countries	Total population (000)[1] (1982)	Arable land (1000 ha)2 (1982)	Number of research scientists[3] (1980)	Inhabitants/ scientist (x 1000)	Arable area/ scientist (ha)
Asia					
Bangladesh	92.9	9 135	1 642	57 000	5 500
Sri Lanka	15.2	2 174	422	36 000	5 200
Indonesia	152.6	19 600	1 473	103 000	13 300
Malaysia	14.5	4 335	822	18 000	5 300
Latin America					
Ecuador	8.0	2 625	276	29 000	9 500
Honduras	4.0	1 769	60	67 000	29 000
Costa Rica	2.3	635	75	31 000	8 500
Argentina	28.4	35 800	1 064	27 000	34 000
Africa					
Madagascar	9.2	3 000	68	135 000	44 000
Senegal	6.0	5 227	105	57 000	50 000
Tanzania	19.8	5 200	256	77 000	20 000
Nigeria	90.6	30 435	1 084	83 000	28 000
Europe					
Italy	56.3	12 415	4 042	14 000	3 100
United Kingdom	55.8	6 978	2 554	22 000	2 700
Netherlands	14.3	862	1 471	10 000	600
USA	231.5	190 624	10 305	22 000	18 500

1. From: World Development Report 1984 (World Bank).
2. 1983 FAO Production Yearbook.
3. Oram, P. A., and Bindlish, V. 1981. Resource allocations to national agricultural research: trends in the 1970s. The Hague: ISNAR.

Major Forms of FSP

Because of its holistic approach, and inherent site specificity, farming systems research has evolved along several lines. Primarily, these are geared to improving varieties and cropping systems but pay less attention to long-term resource management.

ISNAR distinguishes these three complementary approaches to FSP: (1) description of farming systems to understand interactions between various components of the system; (2) on-farm research with a farming systems perspective, directly linked to experiment station component research; and (3) development of new farming systems, which might involve radical restructuring of the entire system.

ISNAR's Perspective on Farming Systems

ISNAR's broad mandate takes a comprehensive view of national agricultural systems, including their linkages with other government and academic institutions, extension services, farmers, and the private commercial sector on the one hand and with international research and donor agencies on the other.

ISNAR's extensive reviews in 17 countries of Asia, Africa, and Latin America have shown that, almost invariably, stronger links are needed between research, extension, and the farmer. We are now studying how well countries that have adopted on-farm approaches have integrated these into their national systems.

In the ISNAR conception, FSP focuses national research on immediate problems, while maintaining the essentially disciplinary and commodity orientation of that research. However, FSP should be organized across different commodity programs so as to coordinate the various on-farm activities. ISNAR recommends that national programs should not develop "new farming systems" but use their funds to strengthen linkages with end users of technology and with policymakers and funding agencies. FSP implies the decentralization of research efforts and building a flexible network for multilocation testing.

Current Status of FSP

A survey begun by ISNAR in 1984 has shown that information on FSP programs varies widely and is difficult to interpret on a uniform basis. Labels may vary, FSP being listed under technology transfer or verification, or FSP may be a part of commodity programs. Far more detailed studies would be needed to determine the actual share of resources spent on FSP activities.

While socioeconomic disciplines are essential to understand properly the human setting of agriculture, national programs have few trained professionals in these disciplines; available personnel usually work at the planning or academic levels and seldom at farm level.

ISNAR country review findings reinforce the conclusion that organization and management problems are major constraints to FSP functioning.

Issues in the Organization of a National FSP

Technical issues

Formerly, technology transfer was viewed chiefly as a "top-down"—research--> extension—> farmer—process, largely ignoring the need for feedback from the actual user. Studies in El Salvador and India have shown that the subsistence farmer, presented with a package of technology vastly "superior" to his current practices, tends to react either by (a) adopting only one or two components at a time or (b) experimenting locally to adapt the given technology to his particular situation.

Such insights have begun to change the overall "top-down" view, and researchers and planners have begun to recognize the need to develop technology in close consultation with its users.

Thus, rather than aim at a notional optimum—with highly detailed and precise single packages of technology—as much Third World research now does, FSP research would be better advised to concentrate on "factor type" experiments, to show both major and interaction effects between components, leaving the precise details to the farmer and extension worker.

Neither research nor extension agencies have as yet fully appreciated the impact of environmental variability on rainfed farming in the semi-arid and arid lands. In striking contrast to agriculture in irrigated or assured rainfall areas—where decisions can be taken *before the start* of the cropping season—rainfed farming requires decisions *during* the season, modified almost from day to day in response to actual weather conditions. Therefore, fixed and precise recommendations developed elsewhere, and often spread at the insistence of donors, become irrelevant to the realities of subsistence farming.

A major task of FSP programs, therefore, should be to separate the components of technology packages, and determine their short- and long-term impact as well as ease of adoption in the overall system. On-farm experiments should try different combinations of the most promising components.

Organizational issues

Donor support for FSP type projects has greatly increased in the last few years. In order to succeed and be integrated into the national program, such projects need stable, long-term funding. It would be desirable for national programs to adopt from the start a structure that recognizes their needs *and* capacity for getting funds and trained manpower.

FSP organization could be of three types. (1) A "minimum FSP" incorporated into existing research programs, especially incorporating socioeconomic disciplines. (2) Coordination of "minimum FSP" activities across commodities and ecozones, through a special coordinator. (3) A separate on-farm FSP team, interdisciplinary and intercommodity, to complement station research.

Generally, small national programs would benefit most from (1) and (2).

Policy and management decisions should be designed to strengthen the important linkages between farmer, research, and support services. Additionally, local teams should be allowed reasonable independence—including financial independence—in organizing daily activities. While planning should be together with headquarters, implementation should allow local teams to respond to specific local needs and constraints.

On-farm research requires considerable managerial skills to

- select representative and accessible sites;
- win farmers' confidence;
- organize field teams;
- provide adequate supervision and adequate transport, lack of which are major constraints in on-farm work; and
- create service conditions that will motivate and properly reward scientists to work in remote areas and in positions less prestigious than academic work.

Proper budgeting of limited resources—especially for major recurrent operational costs for personnel, transport, travel, and housing—and simple administrative procedures to ensure smooth daily functioning of the work are essential.

Implications of FSP Strategy for National Programs

For smoothly functioning and cost-effective farming systems research, national programs should (1) build FSP gradually, to match national resources and capacities and conduct research on a permanent basis, with interdisciplinary units, and (2) back this by, and feed into, research on-station.

Additionally, serious manpower constraints should be tackled by exposing agricultural university students to commodity-oriented interdisciplinary courses, and to interdisciplinary, intercommodity courses on farming systems and on the relations between research scientists and their various clients. Practical field training that brings together students from different disciplines for work on-farm is also vital.

If these conditions cannot be met, then the national program should choose a simpler structure, fewer experiments, and less detailed data collection.

The I ARCs must also be pragmatic in tailoring transfer of their own successful FSR approaches to prevailing conditions in each national program.

Inter-Center Coordination of FSR Activities on a Regional Basis

H.G. Zandstra[1]

The Concern

IARCs have made important contributions in the identification and testing of research approaches that condition the development of technology to the resource endowments of a location. They have stressed effectively that, to conduct such research, close contact with the farm community is needed to appreciate its resource potentials. They also have established that only under farmers' management can we obtain a real estimate of the performance of new technology and understand its impact on household members and on other farm activities.

Simultaneously, and stimulated by the IARCs, national programs have increased on-farm testing of technological components and at times have established fully-fledged cropping, livestock production, or farming systems programs. In several countries, such as Colombia, Ecuador, the Philippines, and Indonesia, important institutional modifications have been made to accommodate on-farm production systems research. None of the institutional forms for FSR is based on commodities, because developing country administrators are well aware that smallholders produce several crop and livestock types on their farms.

IARCs have provided important support for training, research design and monitoring, and information sharing. This support to national programs has led to several IARCs approaching national programs independently with commodity-biased formulations of production systems research. This has led to some confusion and unsightly competition. There are some areas or countries that have received too much attention, whereas others have practically been ignored.

These notes are intended to stimulate the search for a consensus about the way in which the IARCs can collaborate in their support to FSR in national institutions.

Background

IARC activities in FSR have to a great extent been justified to develop methodologies for national programs. There is great variation among the Centers on the effectiveness of the FSR support provided to national programs, often because methodologies were not sufficiently targeted for these programs; they too often presented the image of an activity requiring large Ph.D.-level teams. This image was reinforced by some bilateral donors who encouraged large expatriate research teams.

With one or two notable exceptions, the IARC support for national programs has been insufficient to satisfy the needs for training and for encouragement of FSR

I. International Development Research Centre, Ottawa, Canada.

implementation. Much of the IARCs' effort has gone into the search for general solutions to very broadly defined problems—e.g., land clearing techniques in the humid tropics, or wet-season utilization of Vertisols. Would it not be better to develop the national capacity to address these problems within the context of other factors that will greatly affect the most appropriate solutions?

This emphasis on broadly defined problems has led IARCs to conduct the base-data analysis, design, and testing on a large scale, addressing, for instance, the semi-arid tropics or hydromorphic soils in Africa or other such macrospecifications of production environments. This is most appropriate for base-data analysis, and continued emphasis on this should be encouraged. The base-data analysis, design, and testing of technologies for such broad areas, however, will have to face an environmental diversity that makes it most unlikely that improved technologies or alternative production systems acceptable to farmers will be identified. In addition, the base-data analysis, design, and testing of methodologies generated by such large-scale research will not be suitable for national programs, which are concerned about finding land-use solutions to quite specific land and human conditions.

Many IARCs have limited the scope of their production systems programs to one or more commodities. This limitation would have to be relaxed (as it often has been) if national programs are to benefit from the methodologies and training.

National programs therefore appear to be most helped by support for farming systems research that can accommodate all enterprises of the farm family, and that is aimed at environments specific enough to assure a good fit of technology, yet general enough to be manageable for extension services. This, by the way, does not mean that such research cannot address the potential for new cropping patterns or livestock production systems.

The Tasks of Regionally Coordinated FSR

IARCs could effectively combine their inputs into a region, to develop methodologies for FSR suitable for the limited institutional resources of national collaborators in the region. Research protocols for site description and analysis, design, and testing should be such that local field researchers working in remote locations can apply them.

A regionally based team can undertake research on important production constraints requiring in-depth research, which have been identified in collaboration with national programs. Much of this research can be actually located at on-farm research sites developed by national programs and at national or regional experimental stations. Much of this work will focus on component technologies or subsystems of importance to a number of environments in the region.

A very important task for the combined IARC regional FSR team would be the coordination of an FSR network. Training for national FSR field teams, the discussion of methodological problems and technological constraints at workshops, information and documentation support, and the encouragement and assistance in the establishment of FSR in national agricultural research systems, are all tasks that can be effectively handled by a small regional network team, particularly if augmented by national scientists at critical times.

Suggested Mode of IARC Coordination

1. Establish teams on a regional basis. Teams can be composed to combine disciplinary and commodity expertise appropriate for the region, and will typically have staff from three or more IARCs. These teams can provide the much-needed link to germplasm sources and specialized scientists required for the programs of FSR in the region.
2. The teams can conduct research on selected agroecological environments in collaboration with national programs. They also can provide important support in the form of research on important constraints or subsystems identified in collaboration with national programs. As part of this support, research teams can coordinate the introduction, evaluation, and distribution of germplasm (variety trials) of relevance to the major production systems in the region.
3. The team should be located at an IARC or appropriate regional or national institution that has the institutional strength to accommodate training, the management of workshops and monitoring tours, and the provision of information and documentation services to the region.

Policy Issues of Farming Systems Research

J.R. Anderson and J.B. Hardaker[1]

Introduction

National agricultural research systems or at least their research leaders, may or may not be confused by the multiplicity of approaches to FSR. Certainly protagonists of FSR have gone to some lengths in response to such claims of "confusion." Yet in a field of evolving methods and innumerable challenges, "parallel development" (i.e., simultaneously trying several research approaches) is desirable, if not, indeed, essential, and no one model should be advanced as "ideal". If everything were known and progress linear and according to rule books, there would hardly be any need for FSR at all. On the other hand, there are some difficulties inherent in the FSR approach. If a system is defined very broadly and the research addressed to its improvement widely conceived, there is a considerable informational challenge with the prospect of overload resulting in cognitive dissonance. All this seems to imply the desirability of some concept of "balance" in defining boundaries and detail of a system, and the breadth and depth of research.

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1. University of New England. Armidale, NSW, Australia.

Issues related to reward structures are important in the implementation of FSR and range over questions of self-esteem of the research workers and recognition by peers and leaders in research systems, which translate into professional advancement and satisfaction. It is widely held, however, that OFR/ FSP data are rather "soft" and thus may not be as publishable as more conventional research. A general solution must await a wider acceptance of more pragmatic and impact-related measures of success in research. There may be few overt policy matters per se here. There is a clear need for the research administrators who dominate the promotion system to be made well familiar with FSR, because they can materially affect general attitudes towards recognition, at least within national research systems.

Issues for Young National Systems in Developing Countries

By "young" is meant a NARS that does not have a very long history of major investment in agricultural research and thus has ready flexibility as to the forms of organization that can be invoked over the next several years. The investments may be still sufficiently modest and the overall systems sufficiently simple as to make changes in organizational structures towards an orientation to FSR relatively low in cost and easy to implement.

It is in such young research systems that FSR projects have seemingly proliferated, often funded through foreign aid. A policy matter for the postproject era is the desirability or otherwise of changing national research strategies that may have been modest in their resource demands, in keeping with national abilities, to embrace ambitious FSR activities. It would be unfortunate indeed if a belief grew up that the only way to prosecute FSR was through expensive expatriate involvement at salary levels much higher than those customarily used in such national programs.

Issues for Mature Systems in Developing Countries

By "mature" is meant that the organizational structures of the national agricultural research system have been charted for many decades and the tradition of research is well established along some (probably colonially linked) lines.

Here the incorporation of FSR-type activities will probably cause considerable bureaucratic dislocation. The costs are not only monetary, but occur also in terms of interpersonal relations. There may be a good case for policymakers to move rather slowly in terms of major reorganization, and instead to endeavor to sponsor new forms of collaboration among traditionally separate entities under the banner of FSR initiatives. Distributional goals are increasingly entering into research programming in many developing countries with both young and mature systems. If research is to be addressed to the needs of significant numbers of small-scale farmers who typically produce many different commodities on very modest resource bases, it must almost surely involve OFR/ FSP as the most effective way of potentially advantaging farmers through applied research.

Issues for IARCs

FSR seems clearly suited to the circumstances of national, rather than international, agricultural research programs, since it is specific to the relatively small numbers of farmers in selected locations who form the chosen recommendation domains. With target domains of typical size and scope, the numbers of domains to be studied worldwide make the task clearly several orders of magnitude beyond the present and potential resources of the IARCs. Their mandates are too broad for them to make a major commitment to FSR directed to just the few target groups with which they could realistically cope. Rather, it can be argued, the Centers should be concentrating on expanding the stock of knowledge about the production technologies on which effective FSR by national programs heavily depends.

Yet these arguments are incomplete in two main respects. First, the task of expanding the stock of knowledge for national FSR programs imposes on the Centers a need for relevance in their basic research and prospective technology development activities. Such relevance can best be assured through the feedback mechanisms of FSR. Second, the capacities of national programs to conduct effective FSR often need reinforcing.

As documented in the recent CGIAR Impact Study, the Centers have made many and significant contributions to several of the activities widely agreed to be their logical responsibility, especially through the development of methods and training programs but also through conduct of their own FSR projects.

For better or worse, the Centers will surely be significantly involved in some FSR work for the duration of their existence. Particular caution must be exercised about the cost of such Center-based FSR work. It will provide a better model that could be more readily transferable to national programs in developing countries if it were more cost-effective.

Wider Policy Issues

Thus far the focus has been on policy issues in research management, broadly defined. But there are some more direct interactions between FSR and policy issues. As FSR programs mature and understanding of target systems grows, a better appreciation can be gained of the scope for change and improvement within target domains. This information can be fed back to policymakers and may lead them to revise their priorities and programs.

Research management decisions within programs are seldom, if ever, neutral in their policy implications. Indeed, in those countries where landlessness is a severe problem, research with a farm focus may be too narrow. Attention perhaps should be directed to, say, the development of better opportunities for agroprocessing activities as a means of generating greater improvements; i.e., work with *rural* systems perspective may be needed in place of merely a *farming* systems view.

Given the relatively inelastic demand for most farm products, most gains from FSR-generated innovations are likely to be reaped by the early adopters, while nonadopters or late adopters may actually be made worse off by the change. Who gains and who loses may be partly determined by the initial structural characteristics of the population of farms, maybe partly by luck, but certainly partly by the nature of the technology that the FSR program generates and by how the results are extended to farmers.

Some constraints lie within the realm of policy. Available credit may be lacking or input delivery systems may be too poorly managed to allow potential improvements to the farming system identified by FSR to be taken up by the majority of farmers in the target domain. Marketing systems may be inadequate or inappropriate to handle enhanced marketed surpluses. Research efforts directed to distributional objectives may be thwarted by the existing rural power structure or land tenure arrangements in the target domain. Indeed, a criticism of most FSR is that it is too narrowly conceived.

A successful FSR program should lead, therefore, not only to the development of appropriate improved production technologies but also to an articulation of the policies and programs that must be in place to support and sustain improvements to the farming system. If input delivery or product marketing systems are diagnosed as deficient in an analysis of the constraints to raising agricultural productivity, it surely makes sense to apply the same research approach to the design of improved systems. Postharvest technologies, for example, may be a critical area where improved methods can be developed that will allow the farmers in the target domain to get their produce to market in a better, more profitable condition.

In summary, a case can be made that policy issues are inevitably an integral part of FSR and should be recognized as such. The problems of agriculture in developing countries are too great and too urgent to restrict the search for solutions to the set of possible "technological fixes," when so often and so evidently other features of the system, broadly defined, must also be changed before real progress is attainable. If politicians* sensitivities are too tender to allow a frontal attack on these problems, FSR may serve as a Trojan horse" that may allow at least some advances to be made.

Farming Systems Research as an Analytical Framework and a Tool for Training

H. Mettrick and M. Wessel[1]

The International Course for development-oriented Research in Agriculture (ICRA) is a course for young agricultural scientists working in developing countries. Its goal is to encourage research designed to produce results that are acceptable to and usable by

1. International Course for Research in Agriculture, Wageningen, The Netherlands.

small farmers and that are compatible with the broader aims of governments. It seeks to achieve this goal by promoting an understanding of the objectives of farmers, their existing practices, and the constraints to their adoption of new technologies.

The course combines theoretical training with 3 months of field study in a developing country, which provides participants with a case study of the processes at work in agricultural development and allows them to try out methods of studying these processes, to identify priorities for agricultural research. It brings students into close contact with farmers and requires them to understand local farming systems and to analyze the constraints—physical, biological, social, economic, and political—to the improvement of these systems.

The ICRA experience has shown that the integration of theory and practice by means of interdisciplinary study of farming systems can make an innovative contribution to educating young agricultural scientists seeking to serve small farmers through the development of relevant technology. Given the limited scope and duration of the fieldwork, the studies are inevitably incomplete, but for ICRA the study of farming systems is not an end in itself.

The ICRA approach has much in common with the farming systems research approach, although necessarily only covering the diagnostic phase. Much experience has been gained in handling the problems of implementing this descriptive and analytical stage. (1) The need for more advice on how to proceed from diagnostic survey to researchable propositions. (2) Five years of ICRA courses have led us to believe that interdisciplinary communication can be taught. (3) Our experience in working with culturally heterogeneous groups is that the most serious problems of working together result from differences in experience and in educational and cultural backgrounds.

Review

CO. Andrew[1]

Farming Systems—Perspective/Approach

The paper by Stoop makes some very important points about farming systems as an approach. It is a paper well worth careful reading and one I find easy to agree with in most instances. The points I wish to highlight are the following.

1. The FSR objective is to improve the research-to-client linkage. While this is an important means to an end, I submit that the major objective is to develop and adapt technology suited to farmers to adopt and use as a means to resolving production constraints. In discussing producer-to-scientist feedback, the author affirms this point

1. Farming Systems Support Project, University of Florida, Gainesville, FL, USA.

by indicating that the feedback process provides for the development of suitable technologies for different categories of farmers.

2. FSR should not be considered "a science" but "an approach." FSR is a complement to good basic/fundamental research and to effective extension. If investments are not made by the overall system in good basic research, then the FSR approach will not help, and vice versa. Equally important is that farming systems should not be implemented as "a project" but a means to improving effectiveness of research and extension in a technology development process that is conducive to maximum farmer benefit from research funds expended. Often FSR project failures have been due to poor design, "dubbing" projects in mid-course as FSR projects when they were not, and lack of understanding that FSR is a methodology. A worldwide inventory of projects prepared by the Farming Systems Support Project of the University of Florida may help clarify this issue and identify countries where FSR is established as a methodology.

3. Researchers have not until now investigated reasons behind variability. We could add that research often has neither recognized the presence of that variability nor generally diagnosed the accompanying interactions and constraints so that investigation of the variability is given useful direction.

4. Lack of understanding of broad issues (including variability) explains farmer rejection of technology. Occasionally, farmers can provide for the adaptation that is necessary, but more frequently even large farmers in Florida ask researchers to bring their results "a bit closer to the farm."

5. International and regional researchers must limit efforts to broader issues of contrasting variability; a more extensive network of on-farm research sites is needed by national programs. We agree, but have trouble with this important assertion when the author later indicates that on-farm research should be a minor part of the national research program. It is difficult to prescribe the level of on-farm research appropriate without referring to a specific setting. Similarly, the division of labor between international and national research programs cannot be prescribed to be the same for all relationships. Certainly multilocational testing by IARCs is important, but a balance is necessary that permits this testing to achieve a solid national program linkage.

6. Investments should be in disciplinary and commodity-oriented research that ensures a systems perspective rather than in "new farming systems" research. New farming systems research in many instances avoids farmer adaptability, a critical mistake, but most important is the emphasis on ensuring a systems perspective by discipline and commodity scientists. This is not simply a Third World message but one for "mature systems" to address. The stepwise approach that incorporates feedback through an adaptive research effort and involves farmer participation will strengthen the effective value of disciplinary and commodity-oriented research.

7. Agricultural research in many Third World countries may desire unrealistic precision. This speaks for relying on "science" from the IARCs and more adaptive on-station and on-farm research than is common in national programs. Often, however, the on-station work has a low success ratio, is slow, and is costly.

8. A concept of "Minimum FSP" can be effective in some situations. This does not seem to fit in the otherwise comprehensive statement concerning the need for adaptive

research. The multidisciplinary emphasis through one or more people in a team approach focused on the system is an essential link. The three concepts of "Minimum FSP," "Special Coordinator for FSP," and "Separate On-farm Team" are not necessarily a continuum. The question is one of effectively allowing the farming systems approach to function within the total research/extension process. The risk is too great that relegating a systems perspective to a "figurehead" will abdicate "responsibility" relative to ineffective technology development. And, maybe one could argue that the team concept for on-farm research is even more important for small research systems than the better-endowed, not to exclude the latter. It would seem that this conceptualization also overlooks the important extension linkage.

9. Teams need to be adequately supported through financial, human, and logistical resources. This point is well taken; however, recognition of the limitations of such resources may allow for some adaptation so that research leaders can proceed knowing that the results, while less than optimum, are better than isolated on-station specificity.

10. Linkages between major client groups frequently are missing. This point leads one step further in causality for some countries where external donor programs fracture both management and research-to-extension continuity. In some countries donors may fund different FSR teams.

11. The increasing number of overlapping networks exceeds absorptive capacity in national programs. One might add that overemphasis on networks can detract from the adaptive research necessary. It is not a question of the importance of network exchange but one of careful balance and emphasis.

12. IARCs can transfer FSR approaches. This deserves careful consideration in that "the approach," per se, has many dimensions and should represent a synthesis of all approaches or a possibility to adapt and develop approaches suitable to the national setting, just as technology is adapted for use in a local setting. But to expect that national programs can adopt an organizational structure to suit needs and capacity with ease or rapidity is probably unrealistic.

13. It is agreed there is limited availability of trained professionals in national research programs. But the real question is what we should do about it. Expanded short- and long-term training programs are necessary that target national program needs. The duration of support in many bilateral technical assistance efforts does not always contribute to a fully trained research scientist pool. Often 10- to 15-year programs are necessary to provide the basic and experiential training that is required. We talk and talk about training, but are we making any real headway? Support for national training programs and exchange of experience among those programs, not simply from developed-world universities to Third World universities, is necessary.

Several general comments are stimulated by Dr Stoop's excellent paper. The role of IARC scientists is one that comes into play along the adaptive research or technology development spectrum from basic research to farmer use. Emphasis should be given to strengthening the pool of in-country experts. It may be necessary to involve more IARC staff at that level until the national pool expands in quantity and quality. One precaution among many, however, is that vast differences may result from team-oriented adaptive research where expatriates are predominant, particularly in the socioeconomic positions. Improving the contribution of the socioeconomic sciences to FSR, particularly in Africa, is essential. A good topic for a workshop would be increasing the *effective* participation of the socioeconomic sciences in national research programs. This would be a "follow-on" from workshops similar to the one held in 1984 by CIMMYT in Zambia.

The closing paragraph of the Stoop paper deserves your careful reading even if you read nothing else. The degree of adaptability and flexibility called for is essential. The pragmatic orientation by IARCs to linkages with NARSs through FSR approaches does dictate adaptability to current needs of national programs. With hope, these will change over time as national programs assume greater responsibility through a strengthened human resource base. As this occurs, the research-to-farmer linkage will become increasingly more effective. Only if this occurs will national programs assume viability and be prepared to fully utilize the IARC system to benefit their farmers. Similarly, at that time IARCs will receive a more complete message from farmers about what is possible from their perspective.

IARC Coordination and NARSs

The paper by Zandstra is short and quite easy to follow with numerous "gems" for consideration. I highlight some of the richer points.

1. In human resource development and utilization in an FSR context, Dr Zandstra highlights overemphasis by some bilateral donors on Ph.D.-level teams. The crying need in present and future FSR programs will be for solid, broadly trained individuals who can relate easily to the farmer and the more "science"-oriented researchers. I agree with Dr Zandstra.

2. In the debate about the appropriateness of new farming systems, possibly an important distinction made by Dr Zandstra is the term "new cropping patterns". I am not sure this was intended, but, if not, a distinction of this kind would appear to be much more realistic, if not appropriate.

3. The combination of IARC activities, or coordination, on a regional basis is an excellent suggestion. I am sure it would need a great deal of consideration, but if the IARCs take a lead in this regard, it might very well give leadership within the donor community. The paper makes some good suggestions as a point of departure.

Policy Issues of FSR

The paper by Anderson and Hardaker offers a great deal to agree with, and gives a good general picture of farm and agricultural policy related to the farming systems approach. Possibly one step beyond this paper would be a conceptual framework, so that we might communicate more easily in this complex area, better understand the whole, and finally address issues within that interest so that their ultimate change fits into a macrosystem (sector) in a manner conducive to support for the microsystem (farm).

The points I highlight from the paper are the following.

1. That NARSs are not confused about the approaches to FSR. While much is needed in methodological development, I have to agree with this statement. It now appears that we have reached an additive step-by-step progression in methodological development coming from IARCs, NARSs, and universities.

2. That the professional reward system is skewed away from the adaptive research professional. Here, at least in the university system, and I suspect in IARCs, it is not so much a problem of the "research administrators who dominate the promotion system" imposing standards as it is the peer pressure through professional societies. The power of the discipline- or subdiscipline-oriented professional society is greater in many respects than that of the research/training entity.

3. That if research and extension staff work well together, the need for FSR is reduced. This may be true, but even in "well oiled" R/E systems, specialization can reduce the effective role in understanding farmer production constraints. Good R/E institutional and administrative linkages may be necessary, but not sufficient. It is the interdisciplinary activity that often keeps research and extension work from becoming lumpy, spotty, and vested in subdiscipline interests. We confront this challenge in Florida.

4. That graduate programs in FSR in north American universities will lead to eventual impact on institutional arrangements for national programs. We hope this is true. I believe we must influence these programs in universities to appreciate the need. We have at the University of Florida a farming systems minor at the M.S. and Ph.D. levels, with four assistantships and possibly two to four new assistantships this year. The applications for these new assistantships exceed 135 at this time from more than 30 countries. The demand is there—but will the system respond?

5. Other points that deserve emphasis are the following:

a. Balance of resource commitments between basic/ fundamental and adaptive/applied research.
b. Social relevance of the research program.
c. Need to expand the stock of knowledge in ways that are symbiotic with national programs and support research methods suited to national program needs.
d. Policy importance of target domains.
e. Policy implications of research management decisions.
f. Policy involving the rural system to support the farm system. (I suggest more attention in a systems context is needed with the agricultural sector and subsector systems—an agricultural systems approach.)
g. Tendency to look for technological solutions to policy problems—credit, marketing, land tenure—may be off track but difficult to avoid,
h. Articulate policy from microlevel orientation of FSR to the policy formulation sphere.

6. Lastly, and possibly implied in the paper, is the need for policy research. I believe this must be sector- and subsector-oriented in a systems context. I favor agricultural systems work because it says more at the macrolevel than trying to stretch FSR terms that far. Policy work does not have to imply politics, just as management research does not imply farmer changes in management behavior. Thus, I recommend that all IARC

staff, and especially the socioeconomics people, contribute to agricultural systems considerations and policy work, notwithstanding the role of IFPRI. It seems domain consciousness may be too restrictive for effective agricultural research and development.

Training and FSR

I respect training programs that are oriented to problem-based learning. The paper by Mettrick and Wessel is directed to learning through individual explorations and is one of several experimental learning strategies that departs sharply from conventional curricula, either for short-course or degree-oriented training. Bowden in Australia states that "the conventional educational strategy is to use problem solving as a vehicle for *integration* of knowledge previously acquired. Experimental strategies reflect the view that the investigation of problem situations is the vehicle for the *creation* of knowledge."

To me it is the learning environment that is important, both for students of FSR and for practitioners. I make little distinction between practitioners and students and would like to think that most of us are students of FSR and related systems and need more and better training programs. Not all must attain advanced degrees. A critical mass of human resources would include a healthy balance of varied levels of training.

Some questions I raise are purely operational. Is the training generally conducive to "escape" for national scientists?

Do they need to qualify in any way other than that which will lead to a balanced interdisciplinary group? Are there skill-related expectations relative to the "hands on" experience? How is the program evaluated or validated? Can it be merchandized?

Summary

Overall, the four papers presented prove to be complementary. The activities of organization and management, inter-Center coordination, policy issues, and training facilitate successful technology development in the IARC and NARS sphere. Also, each activity is important to the other—and herein lies the complementarity.

I will confine my comments generally to the areas of FSR style, policy, and training. It seems that confusion of FSR taxonomy and methodology is not really of concern to national programs. There seems to be a general group consensus that we must nurture diversity with harmony.

Possibly most important in the methodology and organization area is that it is time to "pass the ball" to the national programs. Stepwise learning is essential, and the national programs are making the greatest strides in applied methodology and organization relative to FSR.

In the policy area, the papers generally cover the waterfront quite well, and the issues are well stated. I encourage review of the section in the Anderson paper titled "Wider Policy Issues." Beyond that, I would emphasize four points not directly covered in the papers.

1. Diagnosis of policy constraints requires careful interaction with national program leaders. Often they can generalize over several countries. Directors of research and extension programs in West Africa from 18 countries were able to do this last year, and they requested help in four areas.
2. The notion that policy analysis should be carried out primarily by IFPRI should not be construed to restrict other IARCs from being important links in that activity, if not directly involved. We can gain significantly from the various socio-economic units at the IARCs.
3. We need a more expansive conceptual framework to embody the hierarchy of activities that influence research with a farming systems perspective and its impact, inclusive of the interactions with the policy domain.
4. In the context of number 3, we need a broad commitment to policy dialogue and support. This does not necessarily imply involvement in politics, which is ill-advised, but general policy support is essential if the full results of FSR are to be achieved.

Training emphasis is critical to the entire sphere of activities extending from the research/extension dimension through policy analysis. Each paper addressed training. It is agreed that emphasis solely on the M.Sc. or Ph.D. is not sufficient. Also, agreement might include a statement that "more is needed if people receive the 'right' orientation." The experiential learning mode presented by Mettrick and Wessel would complement, I believe, the interests of the three other authors.

The need for a broader orientation in advanced-degree training, I believe, demands that the IARCs take some responsibility for influencing universities to consider curriculum changes to accomodate the need. It is an opportune time to make such a joint recommendation relative to north American universities. Of course, similar concerns might be expressed for developing country universities, but I am making no specific judgments in that regard.

Support needs for training programs were not considered by the authors, but I believe such support and collaboration is critical. Points to consider are the following.

1. Synthesis and exchange relative to training materials and methods.
2. Program components might entail:

a. training trainers balanced with materials development;
b. synthesis of methodology and training experience;
c. documentation support;
d. publication and network follow-up (newsletter and working papers); and
e. balanced curriculum development relative to the theoretical/experiential and disciplinary/interdisciplinary and other distinctions.

Training, even for continuing education purposes, requires long-term investments. Given that the CGIAR has invested heavily in the areas of management and policy, it would seem that an investment in the training support base for IARCs and NARSs would be appropriate.

Chairman's Summary

J.L. Dillon[1]

This session was something of a pet forum, with four papers each on a distinctive topic, the title of the session being somewhat a misnomer since evaluation was not considered (though it was considered briefly in the keynote paper).

Stoop's paper hypothesized on the best course of organizational development for a NARS in its implementation of RFSP. His not suprising conclusion was that the organizational development of RFSP in NARSs should be a staged process, and take place in a balanced way relative to the stage of development and capacity of each NARS itself, and that such development should be on a program rather than a project basis, and should be sustainable in the long term. Supplementing Stoop's paper, Sands outlined an ISNAR project that is just now getting under way, aimed at comparative analysis of a number of implementation arrangements for RFSP by NARSs; such an analysis would provide information on the pros and cons of alternative organizational arrangements for the institutionalization of RFSP in national programs.

Zandstra's paper argued the need for better inter-Center coordination of RFSP activities by the IARCs, on a regional basis, with particular emphasis on the coordination of IARC approaches to national programs. Avenues for facilitating such harmonization of approaches would be through network arrangements involving NARSs and IARCs, and through training activities.

Anderson's paper was concerned with the policy issues of agricultural research ranging from research and management policy within IARCs and NARSs to the implications of RFSP for government policy in the agricultural sector.

Wessel showed in his joint paper with Mettrick how the concepts of RFSP are used in the ICRA training program with its emphasis on giving its trainees an understanding of the farmer's perspective.

Lively discussion ensued, but more in terms of expansion of matters raised in the papers rather than in terms of any significant disagreement with the papers.

Perhaps the major issues raised in the wide-ranging discussion related to the following.

a. Training needs and the desirability of the IARCs jointly organizing training courses and materials.
b. Internal IARC policy implications of RFSP in terms of reward structures.
c. The need for a farm household and community focus rather than simply a farm production system focus.
d. The integration of OFS and RSS and the involvement of station-based scientists in OFR.

1. University of New England, Armidale, NSW, Australia.

Session 5

Integration of Crop/Livestock/Agroforestry and Other Land-use Systems

Chairman: H.G. Zandstra
Rapporteurs: W.A. Stoop, ISNAR/C.K. Ong, ICRISAT
Reviewers: J.S. Maini, and E.A. Luna

Research and Development Strategies to Improve Integrated Crop, Livestock, and Tree Systems

R.D. Hart[1]

Introduction

The goal of agricultural research and development (R&D) is to produce large-scale development changes. This can be achieved by doing research to identify small changes that can be made at critical points, to trigger a series of changes that will lead to a desired development goal. It is difficult to identify these small-scale technological changes without an understanding of the systems that link the target research phenomenon with the target development phenomena.

The hierarchy described in Figure 6 is a typical R&D framework for many crop commodity research programs. The basic premise of many commodity R&D programs is that the introduction of "better" crops will lead to "better" regions. When agricultural systems are relatively simple, an R&D program does not need to allocate much of its resources to understanding the systems that link the target development and target research system. However, if a region has many different types of farm systems, each with many interacting crop, livestock, and tree ecosystems, and if these ecosystems in turn have interacting crop, livestock, and tree populations, resources must be allocated to the analysis of the systems that link population-level (crop, livestock, or tree) technology with the target development system.

Types of Agricultural Systems

To produce a development impact, it must be possible to integrate population-level technology into existing crop, livestock, and/or tree ecosystems, farms, and regions. If crop, livestock, and tree interactions are analyzed and taken into consideration, the likelihood of generating technology that can "ripple up" the hierarchy is significantly increased.

Four general types of integrated systems can be identified: (1) crop/livestock systems, (2) crop/tree systems, (3) livestock/tree systems, and (4) crop/livestock/tree systems. Interactions among crops, livestock, and trees can occur in space (populations found together in the same area), in time (rotation, successions, etc.), or in both space and time. These interactions can be either negative (competition for the same resource), positive (one supplying an input to another), or both competitive and supplementary.

Crop, livestock, and tree interactions can occur at the regional, farm, or ecosystem levels. The hierarchical level at which an interaction occurs is a very important consideration in the selection of an appropriate R&D strategy.

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1. Winrock International, Morrilton, AK, USA.

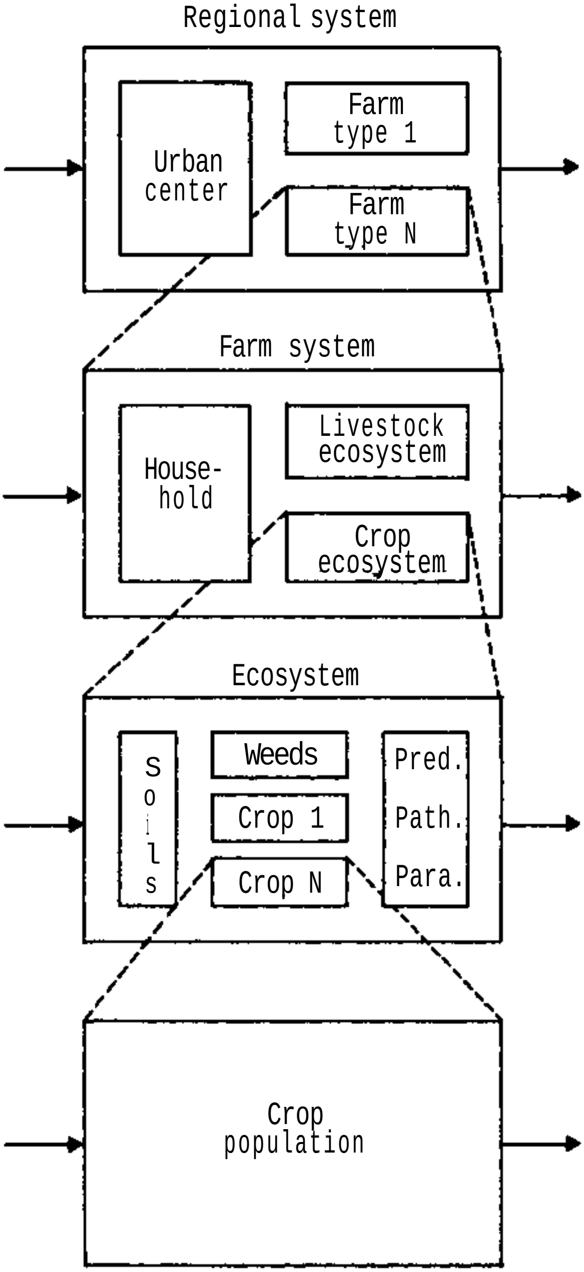

Figure 6. A hierarchy of agricultural systems that can be used as a framework for research and development (Pred. = predators; Path. = pathogens; Para. = parasites.)

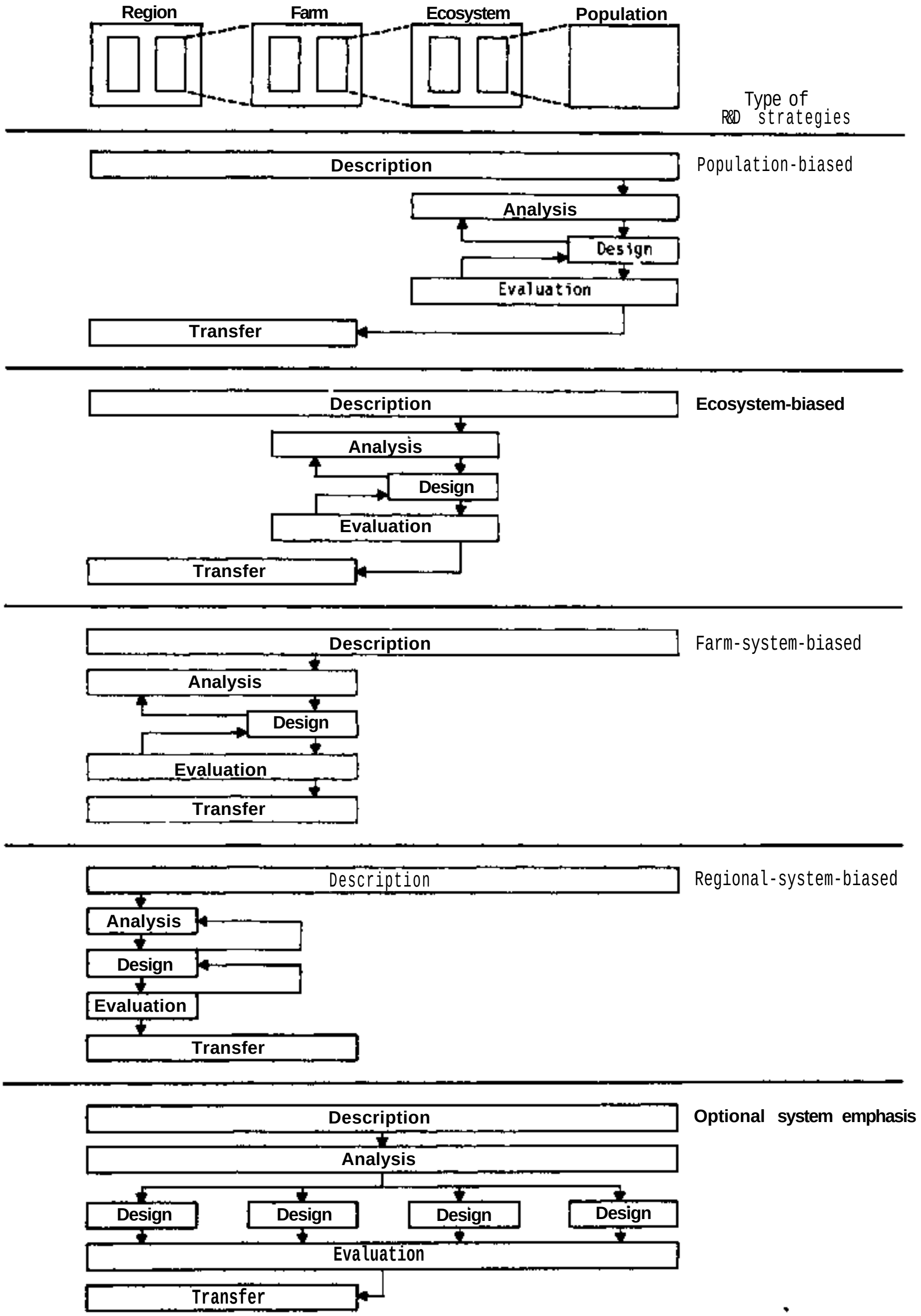

Figure 7. Five types of system-oriented agricultural R&D strategies.

Types of R&D Strategies

Five types of R&D strategies are discussed below and summarized graphically in Figure 7. The first four strategies differ with regard to system emphasis; the fifth strategy has an optional system emphasis that is determined after the systems analysis stage. In all of the five strategies it was assumed that the development goal is change at the regional level. All strategies include a description of the region-farm-ecosystem-population systems hierarchy and end with a transfer phase that is directed at the farm and regional levels. The strategies differ as to the system levels addressed by analysis and evaluation activities because they emphasize different levels at the design stage.

Selection of R&D Strategy Options by National Institutions

The central thesis of this paper is that the characteristics of the agricultural systems that are targeted for agricultural R&D should determine the selection of an appropriate R&D strategy.

Of the five R&D strategies discussed in this paper (Fig. 7), the optional-system-emphasis strategy is probably the most appropriate R&D strategy for national institutions. If, after an analysis of the agricultural systems in a specific region, a population-biased approach to design and evaluation is selected, closer institutional ties to a commodity-oriented IARC can be developed. If an ecosystem-bias is selected, closer ties can be developed with a multicountry network that emphasizes the predominant type of ecosystem. For example, if crop/tree or livestock/tree systems are important, then a closer relationship with an agroforestry support institution could be developed. Other types of networks, such as a livestock production system network recently started in Latin America, are being considered.

Agroforestry Research in a Farming Systems Perspective: the ICRAF Approach

J.B. Raintree and F. Torres[1]

Introduction

The International Council for Research in Agroforestry (ICRAF) is an autonomous, nonprofit research council with a broad mandate to improve the well-being of the

1. The International Council for Research in Agroforestry, Nairobi, Kenya.

peoples of developing countries by promoting agroforestry systems "designed to result in better land use without detriment to the environment."

ICRAFs technology-generating research is done largely through collaboration with national researchers, but the Council is also becoming increasingly involved in the direct staffing and joint management of collaborative research and development projects and maintains close ties with IARCs.

Objectives

ICRAFs main objectives in agroforestry systems research are to: (1) inventory, catalog, and evaluate existing agroforestry systems; (2) develop effective methodology for diagnosing land management problems and design appropriate agroforestry systems; and (3) identify priorities for research and help develop technology-generating research networks.

Present Status

Land use in which woody perennials are combined on the same management unit with herbaceous crops and animals is ancient practice in many parts of the world. "Agroforestry" is a new term that recognizes the need to explore, systematically and scientifically, the role and potential of these woody components to increase, sustain, and diversify production (Table 1). In this field, ICRAF handles both component and systems research.

ICRAFs component research has developed a database on multipurpose tree species, and compiled (and periodically updates) a volume on source materials and guidelines on the methodology for exploration and assessment of multipurpose trees, and has formed an informal network to further this work.

In systems research, ICRAF has inventoried existing agroforestry systems and practices in southeast and south Asia; eastern, central, and West Africa; the American tropics; and the Pacific. This database is maintained on versatile DBMS software for easy retrieval; in addition, ICRAF also publishes a series of system descriptions in the *Agroforestry Systems* journal.

Diagnosis and Design of Agroforestry Systems

In a field of the complexity and scope of agroforestry, a systems approach to research is essential and is mandated in the ICRAF charter. Accordingly, the Council has developed a "diagnosis and design (D&D)" methodology that has a broader diagnostic scope than the general farming systems research approach, and is concerned with conserving resources as well as increasing production. The D&D method is also more deliberately connected with the objectives of the land user, and has a variable scale of application, a more elaborate technology design step, and greater emphasis on the iterative nature of the basic D&D process.

Table 1. Potential contributions of trees and shrubs to basic needs production subsystems.

Food Subsystem

1. Human food from trees (fruits, nuts, leaves, cereal substitute, etc.)
2. Livestock feed from trees (one step down the trophic chain)
3. Fertilizer from trees for improving the nutritional status of food and feed crops through (a) nitrogen fixation, (b) access to greater volume of soil nutrients through deep-rooting trees, (c) improved availability of nutrients associated with higher CEC and organic matter levels
4. Soil and water conservation effected by runoff and erosion controlling arrangements of trees in farming systems (indirect benefits through enhanced sustainability of cropping systems)
5. Microclimate amelioration associated with properly designed arrangements of trees (e.g., shelterbelts, dispersed shade trees) in crop and grazing lands (indirect production benefits)

Water Subsystem

1. Improvement of soil-moisture retention in rainfed cropping systems and pastures through improved soil structure and microclimatic effects of trees
2. Regulation of streamflow of reduction of flood hazard and more even supply of water through reduction of runoff and improvement of interception and storage in infiltration galleries through various watershed protection practices involving trees
3. Protection of irrigation works by hedgerows of trees
4. Improvement of drainage from waterlogged or saline soils by phreatophytic trees
5. Increased biomass storage of water for animal consumption in forage and fodder trees (higher water content of tree fodder in dry season)

Energy Subsystem

1. Firewood for direct combustion
2. Pyrolytic conversion products (charcoal, oil, gas)
3. Producer gas from wood or charcoal feedstocks
4. Ethanol from fermentation of high-carbohydrate fruits
5. Methanol from destructive distillation of catalytic synthesis processes using woody feedstocks
6. Oils, latex, other combustible saps and resins
7. Augmentation of windpower using appropriate arrangements of trees to create venturi effects (windpower is proportional to the cube of wind velocity)

Shelter Subsystem

1. Building materials for shelter construction
2. Shade trees for humans, livestock, and shade-loving crops
3. Windbreaks and shelterbelts for protection of settlements, cropland, and pastures
4. Living fences

Continued

Table 1. *Continued*

Raw Materials Subsystem

1. Wood for a variety of craft purposes
2. Fiber for weaving industries
3. Fruits, nuts, etc., for drying or other food-processing industries
4. Tannins, essential oils, medicinal ingredients, etc.

Cash Subsystem

1. Direct cash benefits from sale of above-listed products
2. Indirect cash benefits from productivity increases of associated crops or livestock

Savings/Investment Subsystem

1. Addition of a viable emergency savings or investment enterprise to farms now lacking one
2. Improvement of existing savings/investment enterprises (e.g., fodder for cattle as savings on the hoof)

Social Production Subsystem

1. Production of goods for socially motivated exchange (e.g., cattle for bride price, ceremonial foods, etc.)
2. Increased cash for social purposes (ritual expenses, development levies, political contributions, etc.)

Linkages with National Programs

Collaboration between ICRAF and national scientists has been established since 1982; 19 institutions have been involved in planning, and 6 sets of research activities are being carried out by national agencies.

While other IARCs tend to be limited by their commodity focus, ICRAF—because of the broad scope of agroforestry technology—may be able to integrate the IARCs' efforts around common land-use problems.

To strengthen the capability of national institutions, ICRAF has devised a networking strategy guided by (1) an ecozone scope for technology generation; (2) interinstitution cooperation at national and zonal level; and (3) in-service training of national cadres on planning and working of agroforestry experiments.

A four-phase plan has been developed for building zonal networks (Figure 8).

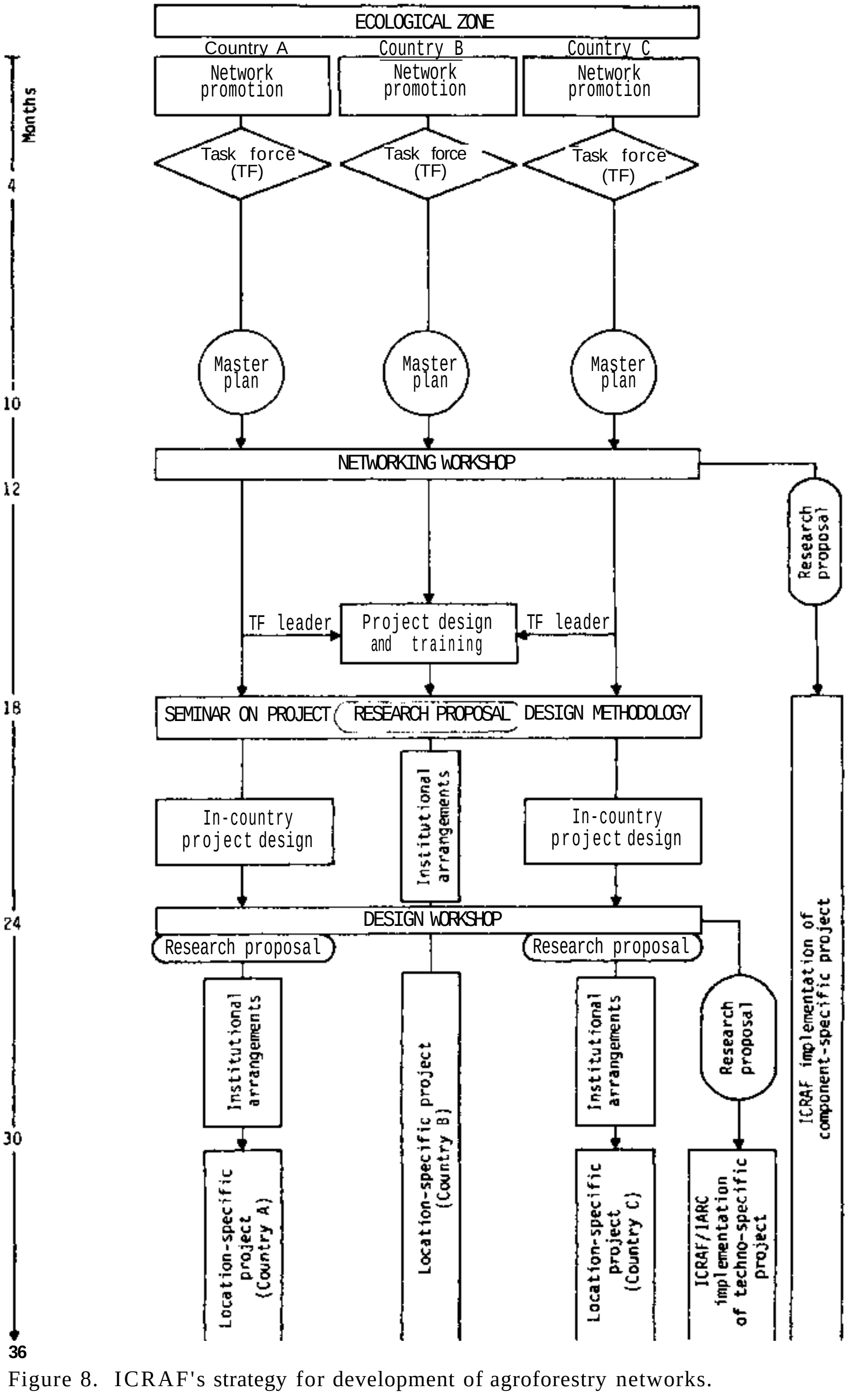

Figure 8. ICRAF's strategy for development of agroforestry networks.

AFRENA

Based on the strategy outlined, the Agroforestry Research Network for Africa (AFRENA) is already being developed to cover four broad ecozones in intertropical Africa: the subhumid highlands of southern Africa, with unimodal rainfall; the subhumid, bimodal-rainfall highlands of eastern Africa; the humid lowlands of West Africa; and the semi-arid lowlands of sub-Saharan northern Africa.

Review (1)

J.S. Maini[1]

Introduction

A number of IARCs represented here have reported a start in activities related to agroforestry. Dr Hart has presented a conceptual and a reference framework to locate the scale of an issue to be addressed, and has made some suggestions on research strategies appropriate to different scales. His notion of "hierarchy of opportunities" is particularly interesting and worth serious consideration. Dr Raintree's presentation described the activities of ICRAF, which can be placed within Dr Hart's framework; i.e., mostly at the lower level of integration. ICRAF, quite rightly, places much emphasis on early involvement of the client, i.e., the farmer. The ICRAF paper indicates that the Council is now moving up in scale to the regional and national levels.

Both presentations subscribe to a systems approach and recognize a hierarchy of systems and subsystems. I am inclined to place Dr Hart's approach in the "systems research" category and that of Dr Raintree in "systems perspective" (of the review remarks by Dr Gomez on the distinction between FSR and FSP).

I would like to make some comments on the use of systems analysis and modeling and transfer of results to the target clients, particularly emphasizing the shift in factors and clientele when we move up from a single farm to country and global levels.

Systems Research

A lot has been written about modeling and modelers. A number of models of interest to this group are biophysical and mechanistic, and have been conceived without adequate consideration of the behavior of individuals and institutions.

Like politicians who want to be reelected, many modelers also promise more than

1. Environment Canada, Hull, Quebec, Canada.

they can deliver, to assure continued funding. Compared with the amount of resources being invested in modeling, relatively few models are actually used in decisionmaking.

There is a need to continue research on systems and systems analysis methodology, as well as on the *application* of these as *tools.* Modeling is not an end in itself; a systems approach, however, is necessary in planning research and technology diffusion activities.

It seems that successful practitioners of systems analysis pursue it as a "craft'' and not as a science. Successful practitioners are: scientifically secure, have made a disciplinary shift in their careers, are enterpreneurial, have good interpersonal skills, have a "horizontal perspective," and keep one foot in the scientific and one in the application camp.

Admittedly, everything is connected to everything else, but some connections are more significant than others. Skill lies in identifying the critical factors and developing appropriate diagnostic techniques (cf. medical sciences and vital signs, e.g., pulse, blood pressure, etc.).

It is important to identify who the client is. Early involvement of the client is necessary. The target client (who changes at different levels) determines the point, time, and scale of entry. Is the client the farmer, community, regional or national government, industry, or other scientific research institutes?

Many scientific institutions and scientists would rather *study, describe,* and *research* an issue than *address* an issue. This paradigm is well illustrated by the vocabulary we use.

Technology Diffusion

CIAT explicitly studies technology diffusion. The problem is not unique to agriculture, and there is a need to examine other fields to learn some insights or new approaches. Introduction of new technology means a change, and management of change and the use of science in public policy have been well researched. There is a need for some insightful analysis; perhaps ISNAR could undertake this.

Hierarchical Systems

A shift in factors and clients is associated with different levels. The nesting hierarchical subsystems, as described by Hart, change from population, ecosystem, farm, subregion, region, country, and globe. It is important to recognize that there are significant differences in the socioeconomic and political factors from lower to upper levels. Examples are given in Table 1.

System functions change with a change in the hierarchical levels. There is a need to understand the behavior of human systems (as emphasized by Ezumah) as individuals and institutions.

Secondly, there is also a need to understand the body politic—decisionmakers, the decisionmaking process, policy process, time horizons of politicians (which differ from those of scientists) as well as the socioeconomic and political realities.

Table 1. Socioeconomic and political factors: differences by level.		
Factor	Farm level	Country level
state	subsistence	postsubsistence
scale	farm, single family	geographically large
driving forces	internal (endogenous)	external (exogenous) political trade
primary beneficiary	farmer	cooperatives, industry, marketing boards
complexity preference	diversity	uniformity
payoff/risk	small and resilient	large and vulnerable
levers of change	internal	external

I fully agree with and support Dr Anderson's recommendations concerning policy-related issues that need to be considered in FSR.

Information Flow from the Scientific Community to the Policy Community

As Dr Zandstra mentioned, the information base is available in research centers but not presented in a form and terms relevant to the decisionmakers. The interest profiles of the two communities differ substantially. For instance, the scientific community has an interest in research, precision, and complexity, it is specialist and has faith in science, and its time scale is scientific. The policymaking community, however has more interest in practical, usable results, and simple solutions; it is generalist and skeptical and its time scale is real.

Future Directions

I support Dr Randhawa's view that there is a need to train experts in planning and policy fields, and Dr Andrew's view that we must promote a wide policy dialogue. If we are to meet the challenges for increased productivity within the shorter time scales emphasized by Drs Randhawa and Simmonds, we must understand the human systems, the behavior of individuals and institutions, decisionmakers (farmers, industry, government) and the policy community.

Review (2)

E.A. Luna[1]

ICRAF, according to its charter, is an autonomous, international, nonprofit organization, with a rather wide mandate "to ... improve the ... well-being of the peoples of developing countries by the promotion of agroforestry systems designed to result in better land use without detriment to the environment." However, what the charter does not say nor give, is the mandate and the resources to carry on the large-scale independent field research that must be conducted as a "Council," not as an institute, following the CGIAR model.

This is a unique situation and represents a refreshing and down-to-earth approach to farming systems research, since ICRAF must, by definition, conduct and stimulate the research needed through the design, establishment, and operation of a wide network of partners.

Dr Raintree states in his paper that only a few research-validated technologies are available; consequently, there is a large task ahead, particularly in the evaluation of farmers' and research technologies, before these can be recommended with confidence for wide adoption. These technologies must be evaluated following a logical, problem-solving approach, similar in its conception, but perhaps with different nomenclature, to those already described and utilized by the previous participants in the workshop.

The fact that ICRAF operates only a small field station in Kenya, devoted mostly to demonstration, training, and limited exploratory research, gives the institutional involvement in technology generation research almost entirely through "outreach" activities.

The paper recognizes the importance of the farmers' role in the direct evaluation of the technologies in on-farm trials, particularly if the farmers'contributions are viewed and judged against the complexity of agroforestry systems and the apparently severe limitations on the use of conventional statistical and economic methodologies in such evaluation.

Lacking experimental facilities of its own and with the limited budget available, ICRAF plays the role of a catalyst for collaboration among national, regional, and international institutions, to conduct meaningful agroforestry research.

The network strategy advanced by ICRAF has the virtue of assembling a "critical mass" of the scientists from many disciplines required for effective research. With this approach, duplication of efforts may be avoided and a better use of scarce, and sometimes dwindling, resources can be achieved. Also, the zonal approach described for the training component will provide more relevant and meaningful opportunities for trainees receiving on-the-job training.

In spite of the rather recent appearance of ICRAF in the field of agroforestry research and development, the collaboration of its scientific staff with the multidisciplinary teams of national research organizations, particularly in the areas of diagnosis

1. Alimentos de Fuerte SA de CV, Los Mochis, Sinaloa, Mexico.

and design (D&D) applications of research and planning, has encouraged several research activities, and some research projects are being implemented. These actions have indirect influence on academic and development institutions in industrial nations, and there are signs of their involvement through the sponsorship of agroforestry-related research projects.

It is relevant that ICRAF has developed a "unique capability" to catalyze the agroforestry composition of its staff operating in an interdisciplinary way, with the additional advantage of having fewer limitations and biases than other research and development institutions. This characteristic may facilitate ICRAFs catalytic role in integrating the research efforts of the participating institutions around common-land-use problems in a wide range of environments.

The concern and the sense of urgency of ICRAF, in promoting research in agroforestry systems in the scale required, is quite justified and welcome when viewed against the magnitude of the needs and problems involved and, particularly, the time constraints in nations' efforts to rationalize the use of their land and forest resources.

The action program modeled by ICRAF to promote effective networks has the merit of focusing on the urgent need to give credibility to national research institutions. Their research capability is strengthened so that they become more efficient in the diagnosis of their real agroforestry potentials and to enable them to design their own on-farm and on-station research. In fact, ICRAF may play a very valuable role, complementing the national program's efforts to identify the research components appropriate to each national situation. The principle of *"integrated planning but independent implementation"* of overall research efforts, which ICRAF advocates for its networking strategy, has the ingredients of a very successful effort, like PRECODEPA—the Regional Cooperative Research Program for Potatoes in Central America and the Caribbean—which CIP promoted several years ago and which is going strong, after a very favorable first external review.

Finally, ICRAF deserves to be commended for the encouraging results obtained to date, which have the merit of having been achieved quietly, efficiently, and with the low profile that limited resources impose. In spite of these limitations, ICRAF has gained valuable experience with land-use systems, in a wide variety of environments, establishing at the same time a track record of institutional collaboration, in a world where everybody wants and does his own thing and where policy issues may complicate and delay, even prevent, achieving the goals established.

Chairman's Summary

H.G. Zandstra[1]

The papers presented by Drs Hart and Raintree cover many methodological concepts and considerations for implementation. It is not possible to do justice to all of these and this report will comment on only a selected few, because of their importance to the overall objectives of the workshop.

The paper by Dr Hart introduces a hierarchy of agricultural systems including the "crop population, ecosystem, farm systems, and regional system." The type of technological intervention, the inclusion of trees and livestock as means of improving land use, and the extent to which community-level resources and marketing and price policies are considered, are given as factors that determine the systems level(s) to be covered by research and development. A good case is made for including all levels at the description and analysis stage ("optional system emphasis"), as a means to identify the most productive intervention points for technology (or policy?) design and evaluation. The importance of higher-level systems for the policy and marketing aspects is stressed—a view also present in the concern for the food system expressed by Rhoades in his description of the CIP approach.

Hart also presents an interesting view of the evolution of the overall international research system (national, regional, and international levels) that would be needed to accommodate agricultural research and development strategies that reflect a systems approach. At the national level, he emphasizes the need for a strong linkage between research and development institutions, and, at the regional level, he mentions the increasing number of multicountry networks, such as the Asian Farming Systems Network, the Latin American Animal Production Network, and the CARDI coordinated farming systems projects in the Caribbean. Hart finds that there is a critical need to allow national institutions to select their own farming systems approaches to research, and pleads for less insistence by IARCs on the use of approaches developed for their own mandates. He indicates that regional (multicountry) networks are needed which can accommodate crop, livestock, and tree components of production systems, and feels that a common approach to farming systems research by the IARCs will do much to obtain this.

The ICRAF approach to agroforestry research in a farming systems perspective was developed later than that of most CGIAR Centers. The authors feel that this has allowed them to "eliminate idiosyncratic elements" and to be more explicit about "certain aspects of the underlying logic." As has been the case with several IARCs it has led to additional terminology. ICRAF's approach as presented in this paper fails to satisfy the description of farming systems research presented by the keynote paper for this workshop: it lacks on-farm evaluation of designed alternative production systems and the development of component technologies. In fairness, the author does indicate that collaborating national programs will conduct this research. This

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1. International Development Research Centre, Ottawa, Canada.

approach probably fits the nature of ICRAF as a Council.

The paper correctly states that ICRAF places more emphasis on diagnosis than most other IARCs, but this reviewer is not convinced that the scope is wider. The claims made by the authors about more of a focus on the land user, a "variable scale of diagnosis," a more elaborate technology design step, and a more iterative "basic D & D process" are in comparison with "the general FSR approach"—something this workshop with all its good intentions could not clearly define. These differences were not substantiated in the paper and do not agree with what this reviewer has seen in other IARCs and national programs. As a case in point, the contention that the design stage in other IARCs refers to experimental design is at variance with a substantial chapter in IRRI's methodology, the farming systems approach described by Chigaru and Avila, in this meeting, and a report of a workshop on Technology Design and Ex-Ante Analyses of the Latin American Animal Production Systems Research Network.

Both papers lacked details about the added methodological complexities caused by considering livestock (particularly bovine) and trees in addition to annual crops in FSR. These were raised during the discussion period. Discussants felt that there was a great shortage of techniques for measuring the performance of crop-livestock-tree based systems. It was, however, widely recognized that the major measurement problem continues to be primary (vegetative) productivity, and that livestock responses to changes in primary productivity were fairly predictable. Problems of interactions between trees, crops, and livestock continue to be difficult to document sufficiently.

The discussion also raised the danger of researchers placing too much trust in farmers' perceptions of technology performance, an aspect that may ignore the long-term effects of land degradation and other social costs.

A particularly effective plea was made for a greater consideration of food trees such as peach, palm, breadfruit, and plantains as the basis for a major component of land-use systems for the low humid tropics.

In conclusion, the tree and livestock component of farming systems can provide important additional tools to researchers for the development of improved stable production systems. Cross-IARC development of low-cost FSAR research methodologies suitable for national research programs would appear to be a high priority. Such developments should be conducted in close collaboration with national programs, possibly through inter-IARC regional networks.

Session 6

Viewpoint on FSR Country Programs

Chairman: J.K. Coulter
Rapporteurs: J. McIntire, ILCA/D. Sharma, ICRISAT
Reviewers: L. Fresco, and P.R.N. Chigaru

Farming Systems Research and Development in Indonesia

A.S. Karama[1]

Introduction

Indonesia is an agrarian country whose agricultural research has expanded substantially in the last 15 years. Strong links with IARCs, chiefly IRRI, have helped develop farming systems research in the country. This paper focuses on the collaboration between the Central Research Institute for Food Crops (CRIFC) and IRRI.

Farming Cropping Systems Research and Development in Indonesia

Research in farming systems in Indonesia began in 1970 as three replicated trials in the experimental farm of CRIA (then CRIFC) at Bogor. Though the experiment bore little applicability under farmers' field conditions, it did show that the use of agricultural resources could be improved.

Surveys conducted among farmers in different areas analyzed cropping patterns and the rationale behind them. Based on these, on-farm research was started at two sites in 1973; its main aim was to increase crop production in ways acceptable to farmers.

With funding and technical assistance from such international agencies as IDRC, IRRI, USAID, and the World Bank, the R&D work has now extended to more than 40 sites, covering a range of agroecological zones. Additionally, pilot projects and multilocation testing have been set up on a series of sites across the islands of Indonesia.

Organization

What began as a small multiple-cropping section within the Corn and Sorghum Agronomy Program of CRIA expanded to include extension, economics, and production programs, and in 1973 became a formal interdisciplinary working group led by CRIA agronomists.

Today we have a national program leader to coordinate cropping systems research within CRIFC and national farming systems coordination within AARD (Agency for Agricultural Research and Development); other institutes, universities, and ministries also participate in it.

I. Sukarami Research Institute for Food Crops, Padang, West Sumatra, Indonesia.

Adapted Cropping Patterns

The major results of research done since the early 1970s may be summarized as follows:

In fully irrigated areas (Java, Bali, Sulawesi, and Sumatra) two consecutive rice crops plus one upland crop is a well adapted system, widely used.

In partially irrigated areas, it is possible to grow two rice crops, followed by an upland crop, if the first rice crop is direct-seeded and the second crop transplanted without tillage. Other good crop combinations are: one rice + two upland crops; or one rice + one long-duration upland crop.

In lowland rainfed areas, a system of one rice crop plus two upland crops works well; soybean, maize, and mung bean grown after lowland rice need no tillage.

In humid upland areas, five crops are possible but not always grown, because of such constraints as lack of good seed and the turnaround time required (with manual labor). Tree crops give excellent cash returns and grass for cattle feed fits well into the system.

In dry regions, maize replaces rice as the major crop and may be intercropped with grain legumes or cassava.

In tidal swamps, a raised-bed-and-furrow system permits growing of cassava, vegetables, and tree crops, and possibly two early-maturing rice crops.

Links with IARCs

The strongest link is that of CRIFC with IRRI, which has supplied technical assistance, personnel, and training for research and extension workers, both at IRRI headquarters and in Indonesia. IRRI has also helped obtain funding for research and supplied materials such as seed of new varieties, new agricultural chemicals, and farm equipment. Some linkages also exist between the Indonesian farming systems program and other IARCs, namely ICRISAT, IITA, CIAT, CIMMYT, AVRDC, and IRAT.

In recent years, as the country's research capability has increased and more trained national scientists are available, Indonesia has also directly sought technical assistance from donor agencies in collaborative programs.

Farming Systems Research—Indian Experience

N.S. Randhawa[1] and J. Venkateswarlu[2]

The Setting

Semi-arid and arid lands occupy about 70% of the arable area in India, with an annual rainfall ranging from 375 to 1125 mm. The population of these areas totals about 340 million. Land holdings are generally small—less than 2 ha—and, with poor, infertile soils and unreliable rainfall, crop yields fluctuate widely from year to year.

Farming Systems Research

FSR in the Indian context has been conducted by the Indian Council of Agricultural Research (ICAR) and its various centers in the country. In the early stages, FSR consisted mainly of testing research results on farms, in simple nonreplicated trials. Since then, FSR has followed the following sequence: (1) regular on-farm experiments to identify and quantify the effects of improved practices; (2) national demonstrations on the production potential of new crops and cropping systems; (3) operational research; and (4) long-term development on a watershed basis.

Thus, FSR finally aims at conserving and, where possible, improving, the soil, water, and biological resources.

Research efforts in India to improve productivity were begun in the early 1930s. In the mid-1950s, an expanded effort was started to reduce soil erosion—a very serious problem especially in the semi-arid lands—and moisture conservation. Contour farming and mechanical soil conservation measures, such as earth banks, terraces, and runoff channels across the slope, were tried. The length of the growing season was determined, to permit the selection of crops of suitable duration. For instance, at Bellary located in the Vertisols region of India, improved short-duration varieties of sorghum and cotton crops grown in the postrainy season period gave substantial yield increases.

AICRPDA

A renewed interest in dryland farming—created by the advent of high-yielding hybrids and varieties, especially of the coarse cereals—resulted in the setting up, in the early 1970s, of the All India Coordinated Research Project for Dryland Agriculture (AICRPDA), with 23 centers around the country, and multidisciplinary research teams. About 2000 ha of farmers' fields were "attached" to each center for testing of

1. Indian Council of Agricultural Research, New Delhi, India.
2. Central Research Institute for Dryland Agriculture, Hyderabad, India.

Table 1. Effect of critical irrigation on the yield of crops.

Region	Crop	Seasons averaged	Yield (kg ha^{-1})	
			Without irrigation	With one irrigation of 5 cm
Dehra Dun	Wheat	4	2140	3550
Varanasi	Barley	2	2600	3360
Ludhiana	Wheat	4	1920	4110
Agra	Wheat	2	2190	2740
Bijapur	Sorghum	5	1650	2360
Bellary	Sorghum	4	430	1270
Solapur	Sorghum	5	980	1820
Rewa	Upland rice	4	1620	2780
	Wheat	4	570	1880

research results in real-farm situations. The overall aim was to develop simple and easily implementable practices to increase yields by at least 100%, and stabilize them.

Improved cropping practices—proper tillage, timely sowing of suitable crops and varieties, optimum plant population, timely weeding and pest control, plus moderate use of fertilizer—increased yields by at least 100%. When these practices were adopted with proven soil and water conservation systems as a base, significant yield increases resulted. Sorghum yields in Vertisols at Bellary and Bijapur, for instance, increased from about 550 kg ha^{-1} in the 1930s to over 2100 kg ha^{-1} in the mid-1970s.

Various systems of in situ rainwater management, recycling of runoff water, and of groundwater recharge have been tested. Runoff collected and used for critical irrigation has been found to give an especially high payoff—about 200 kg ha^{-1} per cm for cereals crops (Table 1).

Alternative Land-use Systems

In India, because of severe population pressures, marginal lands which ought to be under pasture or forest are often cultivated for food crops. Erosion, silting up of reservoirs and irrigation channels, and all the attendant problems, result. Suitable blends of arable crops and woody perennials—such as custard apple in Andhra pradesh, *Prosopis cineraria* in Rajasthan, and *Leucaena leucocephala* in the Alfisols and Vertisols around Hyderabad and Solapur—are now being tried in new land-use systems to overcome these problems.

ICAR has also identified suitable new land-use patterns and conservation measures for areas as vastly different in their needs as the high-rainfall, shifting cultivation systems of northeastern India and the Aridisol areas of western India.

Pastures and animal production play an important role in the economy of dryland

India. Trials on optimum stocking rates for natural and improved pastures have been carried out in Hyderabad and Jodhpur.

Watershed Development Approaches

Indian agriculture in the 20th century has passed through three major phases: (1) near-stagnation, 1900-49; (2) planned development and new technologies based on scientific research, supported by a wide range of services, public policies in land reforms, procurement policies, irrigation, etc., 1950-84; and (3) the present phase, started in 198S, which aims at improving marketing and trade, providing an institutional framework for minimizing the handicaps of small farmers and maximizing benefits through intensive agriculture in small holdings, improving the land and labor productivity, generating employment, and augmenting family incomes.

The strategy for development in the remaining part of this century is thus directed towards more efficient land and water use, based upon soil and water conservation, water-harvesting, and optimum utilization of available sources of renewable and nonrenewable energy for each watershed. The objective is to build a national food security system by stabilizing farm production at higher levels and provide more employment and income to the rural poor, especially in rainfed areas.

About 4400 microwatersheds, on 4.2 million ha of land, are being developed. Of these, 47 watersheds are being supervised for integrated development by research organizations to serve as models. Besides this, 12.8 million ha have been brought under various farming practices for rainfed areas under an extensive development program. With World Bank assistance, four areas of about 30 000 ha each have been identified in the states of Karnataka, Maharashtra, Andhra Pradesh, and Madhya Pradesh for improved rainfed farming, combining crop production and water conservation.

Other considerations included in the overall plans are: personnel training, social scientists' collaborative work with farmers to plan the management of capital assets and ensure that benefits are equitably distributed, and economic evaluation of cost-benefit in the various traditional and new farming systems.

On-farm Research in Ecuador: Current Status

A.F. Munoz and V.H. Cardoso[1]

Introduction

In the search for new agricultural alternatives to improve production efficiency, the Instituto Nacional de Investigaciones Agropecuarias (INIAP) has established a Production Research Program. This program focuses on production systems that are the result of complex interactions between a number of interdependent actions. INIAP's research efforts are aimed at selecting and improving one or two activities that will rapidly and substantially benefit the farmers. Other activities will be included stage by stage as research and experience progress.

PIP: Production Research Program

INIAP is the national agricultural research institute of Ecuador, established in 1962, and charged with organizing research for improving the country's overall agricultural productivity. Until 1976, this was done basically at two levels: research on the experiment station and regional trials on farms—relatively large farms, to ensure reliable statistical data. However, as we recognized that small farmers are a major production component in the country's agriculture, we added a third, small-farm level, to the program. This aims at developing and verifying new technology suited to the particular needs of small farmers and at closing the wide technological gap that had traditionally existed between subsistence and commercial agriculture in Ecuador.

The Production Research Program was set up in 1979, within INIAP, with help from CIMMYT; later, in collaboration with the International Potato Center (CIP) and Cornell University of the USA, the program was expanded to other locations in Ecuador.

This program's objectives are (1) to select and test in farmers' fields technological innovations designed on the experiment station; (2) to provide feedback from farmers about the possibilities and limitations of tested technology; and (3) to formulate technological alternatives, subject to economic validation, for diffusion through extension services.

Our methodology is designed to clearly identify production-limiting factors and to evaluate the economic impact of proposed technological alternatives in the context of the farmers' production systems.

Work areas are defined in terms of "recommendation domains" which group together representative farmers in similar circumstances, with common problems, and who present a homogeneous development potential. Random sampling of farmers is done within these domains to assess their goals and the limitations to productivity.

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1. Instituto Nacional de Investigaciones Agropecuarias, Quito, Ecuador.

Based on the sampling information, technologies are selected and tested in farmers' fields for yield data. Market characteristics of inputs (availability, price, etc.) and of products (transportation costs, price to farmers, etc.) are studied simultaneously as they may affect adoption. Finally, an economic evaluation is made of the technological alternatives in the light of combined analysis of the data from field trials, surveys, and market studies.

Because the research is conducted on the farm, under the farmer's own conditions, the farmer is an active and responsible participant in the process. Thus it is vital to base the research on an accurate understanding of the farmer's circumstances, and we consider the agro-socio-economic diagnosis, systematically describing and analyzing the farmers' conditions and goals—the most important activity of the procedure.

High-risk technologies for the farmer—genetic improvement, new or modified cultural practices, phytosanitary controls—are researched on the experiment station and tested and adapted on farmers' fields. Field days, courses, seminars, and field demonstrations are used for transferring proven technology.

The final step is to evaluate the level of adoption as feedback to the research program.

For each production cycle, we start over again the four-stage process of our applied production systems research—description, design of technological components, research at farm level, and transfer of technological alternatives. Using this method, alternative technologies can be formulated and experimental adjustments constantly made to adapt them to the socioeconomic and biophysical constraints faced by the farmer.

The PIP Approach: Experience and Lessons

Because Ecuador lacked a formal extension program and because we found an implicit disarticulation between the technology offered by INIAP and that actually needed by farmers, we changed our approach.

First, we made several base-line studies—with help from CIMMYT—of the target areas, including agroeconomic and social aspects of the production systems. The new PIP strategy was tried out in several areas where wheat or maize were the basic crops, both to validate technology generated on the research station and to get feedback for adapting it. Later, in collaboration with CIP, INIAP identified constraints to potato production in two important growing areas. Again the base-line study told us what potato growers were actually doing, what technology they needed, and how far they would cooperate with us in testing improved technology.

Preliminary results from the new approach were so encouraging as to attract the attention of both national and international institutions. Other projects now include (1) the Integrated Rural Development Secretariat, created to help small farmers in depressed areas, and (2) Cornell Univesity-INIAP collaboration on PIP programs in two bean-growing areas of Ecuador.

Future Trends

Traditionally, our research institute concentrated on developing technology for commercial agriculture; our technological recommendations had little relevance for the small farmer. It has taken us almost 15 years to recognize that small farmers are the major production component in our agriculture, with physical, economic, and technological limitations vastly different from those of commercial farmers. Eight years of trials on the small-farm level have convinced us of the importance of improving the productivity at this level, and INIAP now clearly sees its role in developing technology for both commercial and subsistence agriculture.

Farming Systems Research Experience in Eastern and Southern Africa

P.R.N. Chigaru and M. Avila[1]

Experience with FSR in Some African National Programs

Considerable FSR experience has been gained by international and national organizations in developing countries. Over the past decade several countries in the eastern and southern African regions have initiated FSR/OFR programs: Botswana 1975, Lesotho 1979, Zambia 1980, Malawi 1981, Western Sudan 1981, Swaziland 1981, and Zimbabwe 1981. At a recent CIMMYT-sponsored workshop in Lesotho for team leaders and senior scientists, participants highlighted three major areas in which FSR has made useful contributions: knowledge of traditional production systems, farmer-extension-researcher linkages, and development of technological recommendations.

Participants of the Lesotho workshop also identified and discussed a number of major problems affecting their programs, namely, donor or IARC coordination, inter- and intra-institutional coordination and communication within the country, and administration of financial and logistic resources, as well as research team composition and management, methodological development, and technical content in less favorable regions. Accordingly more work and experimentation are needed to improve the appropriateness of the FSR models being used in national programs. Since relevant conditions and problems in the research and extension process will vary from country to country, FSR models will have to be designed to fit each set of particular conditions and problems.

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1. Department of Research and Specialist Services, Ministry of Lands, Agriculture, and Rural Resettlement, Harare, Zimbabwe.

The FSR Model in Zimbabwe

The tremendous success of agricultural development in the large-scale commercial sector of Zimbabwe can be attributed to the skillful implementation of appropriate government policies and effective communication between farmers, development or extension officers, and researchers from different institutions. As far back as 1909, for example, trials were being established on farms, and by 1922 more than 300 farmers were participating.

In the extension organization, AGRITEX, the Monitoring and Evaluation Unit, is conducting studies to identify socioeconomic and institutional constraints to technology adoption, and the Institute of Agricultural Engineering is developing appropriate technologies for animal draft and grain storage. In all provinces, AGRITEX teams have established experiments with and demonstration for farmers.

OFR in the communal areas has been a major thrust in the Department of Research and Specialist Services (DR & SS) in the last 2 years. Such research basically consists of formal and informal surveys (approximately seven have been carried out by its various institutes and units) and on-farm research trials: 23% deal with maize, 20% sorghum, 12% groundnut, 9% sunflower, 4% soyabean, 8% millets, 5% cowpeas, 1% field beans, 15% cotton, and 3% forage legumes and veld reinforcement. The FSR Unit has recently initiated trials on crop residue improvement for feeding draft animals. Most of these trials are in their 2nd year and thus will continue for the next 2-3 years.

Because of the dramatic increase in OFR work, the FSR Unit has attempted to clearly define its role in the DR & SS in terms of serving as an effective link between researchers, extensionists, and development planners.

However, the traditional African system of communal agriculture—where each household owns its own crop and livestock enterprises privately but uses communal grazing areas—represents 95% of the farming households. Here, such linkages must be developed to reduce the productivity gap between the commercial and communal sectors. Therefore several national institutions have initiated OFR programs and, in the DR & SS, on-farm research in communal areas has been a major thrust in the last 2 years.

Organization of the FSR Unit

The FSR Unit in the DR & SS is an autonomous unit with a five-member core team and three-member field teams. On-station scientists' contribution is substantial in that they provide reviews of relevant past research, assist in diagnosing production problems and opportunities in situ, and participate in designing OFR. This direct involvement has obvious implication for their own setting of priorities for on-station complementary research. Extension staff and organized communal groups actively participate in the research. ILCA, CIMMYT, and IDRC play a special role in providing experienced scientists to complement and build on the FSR Unit's work.

Methodological Steps

The stepwise procedure followed by the FSR Unit has several noteworthy points.

1. Several diagnostic methods have been sequentially employed as needed in each phase.
2. Methods and procedures selected promote team interaction.
3. Team work and analysis are the modus operandi.
4. Planning meetings have been extensively used to improve research design, determine complementary on-farm research, and obtain relevant information from other research work in Zimbabwe and elsewhere.

At every step in the design process, decisions are made on the basis of actual on-farm, community, and exogenous conditions. Target groups are precisely defined and researchers also define nontechnical elements that need to be eased or changed (credit, markets, roads, etc.) to promote particular innovations among farmers. These should be formulated into policy recommendations for communal area development.

By 1986 the FSR team will have become completely staffed by national scientists with no expatriate permanent staff.

Role of IARCs in Africa

The stated objective of all IARCs is, within their own field of expertise, to strengthen national research organizations and assist them in improving their efficiency. In Africa, they must take cognizance of the fact that national research systems are quite diverse in terms of their institutional development, including the availability of adequately trained and experienced manpower.

Most IARCs have stated that their research activities are meant to complement those of national research groups. Each IARC has a comparative advantage in assembling experienced international scientists at key locations and in moving information, technology, germplasm, and other materials internationally. In contrast, the comparative advantage of national research groups in Africa lies in their ability to undertake the adaptive research essential for fitting new technology into specific and local farming systems. Unfortunately, this ability is dependent on the state of development of a given national program and the resources available to it. It may not therefore be possible for some national programs to carry out the tasks expected of them by IARCs.

In this regard, the IARCs could help conduct diagnostic assessments of national programs in order to establish the most appropriate ways of assisting those of reasonable strength on the one hand and the least developed ones on the other. In such a task it would be useful if the IARCs evolved a coordinated strategy and approach so that they could collectively complement national research groups.

Thus, the IARCs could serve as catalysts or promoters of cross-fertilization activities among national programs through effective networking. This would allow the more experienced African scientists or the better developed programs to assist the least developed ones.

Review (1)

L. Fresco[1]

The two papers from Ecuador and Indonesia bring up several interesting points.

In the first two, particularly, it seems that farming systems research mainly consists of (1) on-farm experimentation, and (2) diagnosis and design. I believe this is true for most national programs.

Perhaps, then, the central question asked earlier in the keynote paper by Plucknett, Dillon, and Vallaeys should be slightly rephrased. Instead of asking what has farming systems research in the I ARCs to offer to national programs, we should ask two more precise and related questions. One is: has farming systems research in the IARCs more to offer than on-farm experimentation and diagnostic methods? And, secondly, how useful are the present methodologies of experimental design and diagnostic methods? How useful are the methods today as they are currently offered by the I ARCs? And in what way are these methods being changed and adapted by the national programs? I believe these two questions focus more clearly on the questions of "who has what to offer to whom".

If I look closely at the two national programs, most of their work appears to be very good commodity research; I am not quite convinced that it is all farming systems research in one of the wider definitions. If adaptive commodity research is easily integrated with the national food crop production programs, then perhaps the whole discussion we have had on the need for integration of farming systems research, the modes of integration, and assisting farming systems research in the national programs is off the point. The call for integration of farming systems research within national programs perhaps shows more of the confusion on the side of donors and I ARCs than it shows on the side of the national programs. Obviously, the examples from Indonesia and Ecuador show quite clearly that there is no problem with this. So maybe we are stating the problem the wrong way.

I do not think the examples from Ecuador and Indonesia show an urgent need for farming systems research methodology from IARCs to go to the national programs. In fact, the national programs can probably teach a lot to the IARCs in this respect. So, perhaps, the national program leaders at some stage in this discussion can try to spell out in more detail what it is they want from the IARCs in terms of support for FSR methodology in the future.

Another issue I would like to touch upon briefly is that most of the on-farm experimentation as has been described by us is limited to the cropping systems level. And, as we discussed yesterday, that in itself is very complicated, especially if we include the livestock component. Nevertheless, I would like to emphasize the need for a more complete systems approach, not just looking at the cropping and livestock systems level, but also at the higher levels in the hierarchy. I think the model proposed by Hart is very useful in that respect.

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1. Agricultural University, Wageningen, The Netherlands.

There is one aspect that I would like to highlight: even if we solve the problems of national trials set up for livestock, trees, crops, and so on, there are still a number of other problems that remain. In particular, how can we test hypotheses relating to such complicated issues as labor input, household allocation of resources, and decision-making in the household? There is very little methodology to test hypotheses in that respect. It's still, I think, one of the areas of farming systems research or theory that is not sufficiently covered. And perhaps this is an area where more thinking is required and more collaboration between the national and international programs. If the ultimate objective of farming systems research is development, we obviously need to know not only if something is working at the cropping systems level, but also whether it has an impact at higher systems levels, and what kind of impact, and what we can expect from it. Trial and error is too risky for many farmers, so we need to know something more, particularly with respect to labor allocation.

One point I find interesting is that in Indonesia and in Ecuador agroecological zones are clearly distinguishable, with distinct cropping systems within each of them. Now, within each of the cropping systems, are all types of farms addressed or is a distinction made between different types of target groups? Is there a particular focus on small farmers only? Is a particular farm size and farm type selected within the cropping system and agroecological domain or is the whole range covered? I ask that question because some eastern African farming systems research focuses particularly on small farmers as the most important target group. This might be a point to discuss later.

The Ecuadorean and Indonesian programs have used IARC technology and methodology, and I have several questions about this: How do they evaluate the technology? How useful has it been, and how have they monitored the adoption of the technology? What changes have been made by farmers and what changes have been made by the national programs? How have these been fed back to the IARCs? This is really one of the crucial issues for discussion.

Finally, how are the linkages worked out with extension and also with universities and breeders? Extension becomes a crucial point only if we start talking about national programs. The linkages between extension and farming systems research are always somewhat difficult. Problems relating to institutional issues come up and many programs I know have difficulties in actually linking up with extension. In this repsect, I wish there were more people here with experience of the French farming systems research programs, because they involve extension right from the first diagnosis. In Indonesia that is what is now being done and I think there is something to be learned from that experience. I think that a decisive point in the French approach is the belief that, in order to understand the system, you have to start changing an element in it. You can't understand it just by looking at it from the outside.

Review (2)

P.R.N. Chigaru[1]

I come from a country that has a dual system in its agricultural industry. When Zimbabwe became independent in 1980, we inherited an agricultural industry that has a large-scale commercial farming sector, which contributed the majority of the marketed produce in the country, and a communal or peasant sector, which contributed very little—at least to the market, because the producers were mainly subsistence farmers.

On-farm research is not new in Zimbabwe. There has been close collaboration or association between researchers and farmers in the commercial sector since the 1920s. This ensured the precise definition of production constraints and researchable problems and ensured quick feedback on the profitability and acceptance, under practical management conditions, of technological innovations produced by the research workers.

These linkages between the farmers, researchers, and extension workers did not exist to the same extent in the communal or peasant sector. It is only after Independence in 1980 that we have tried to achieve a similar setup for the communal sector, without, of course, decreasing the effort made for the large-scale commercial sector, because it remains a very important and significant producer of food for Zimbabwe.

To look briefly at the on-farm research activities in the region, I think it is fair to say that the IARC that has been most active in eastern and southern Africa in promoting on-farm research activities—please note I am not using farming systems research—is CIMMYT, which has been the front runner in this respect. Over the past 2 years, CIMMYT staff have been running regional training workshops at the University of Zimbabwe that have included participants from Sudan, Ethiopia, and even some countries of West Africa. In November 1985, CIMMYT organized a workshop in Lesotho which brought together team leaders and senior scientists to identify progress, needs, and problems they have encountered in African countries in trying to carry out on-farm research programs. Participants in that workshop highlighted three main areas in which they felt on-farm research activities could have made useful contributions.

1. Knowledge of the traditional systems in the small-scale farming sectors. Participants generally agreed that the studies they had initiated—and most of these studies are not more than about 5-10 years old—have led to an understanding of social and cultural issues underlying existing farming systems, the status of the various components of these systems, and an assessment of critical constraints such as labor bottlenecks, shortage of draft power or labor or cash, soil fertility and weed problems, etc.

2. Linkages between farmers, extension workers, and researchers, a critical area that Dr Fresco also highlighted. Through on-farm research we have seen more

1. Department of Research and Specialist Services, Ministry of Lands, Agriculture, and Rural Resettlement, Harare, Zimbabwe.

dialogue among these three major groups; this has been absolutely indispensable in the identification of constraints, and of possible technological interventions, and in the drawing up of research plans. Such an interaction has been achieved by field days, held on some of the on-farm experiments, with a sharing of responsibility for trial supervision on-farm between extension staff and researchers.

3. Formulation of technological recommendations, or rather, recommendation domains. All agreed that this had to be a major output of their programs, but that it was too early to claim any successes or to assess any impacts of introduced technologies. However, there are a number of interventions that appear very promising, at least in the testing process: techniques of land preparation and planting techniques, e.g., use of double plowing, winter plowing, etc.; the management of fertilizer, herbicides, and insecticides; introduction of new crops in some systems; and testing of new genetic material for traditional crops. These are beginning to have an impact, but it is still too early to judge if adoption is widespread.

Participants also described the problems and needs in their particular countries.

1. Objectives of donors or of the government. There is a feeling that there are unrealistic expectations of quick results and not enough support for institutional building and formal training.

2. Uncoordinated farming systems research projects within the country. Good examples that come to mind are the programs in Zambia and some of the ones in Malawi, and a proliferation of regional workshops on on-farm research related approaches. There is a feeling that CIMMYT, in particular, although well meaning, tends to call too many workshops.

3. Institutional organizational aspects. Misunderstanding or friction or competition between commodity or disciplinary researchers is evident in some countries. The gulf between extension and research personnel in terms of training and status, which affects the linkages I was talking about earlier, inadequate horizontal channels of communication across research units, and between people involved in on-farm trials, lack of influential links in some cases between policy and support systems, all slow down the formulation of farmer recommendations. With regard to administration, problems included late project start-up, lack of adequate resources and support for fieldwork, internal transport and subsistence allowances, and delays related to input procurement. And these obviously affect the attitude towards and faith in the program by the farmers who contributed their land.

4. Composition of teams and management of on-farm research. In most countries, there is a lack of qualified staff, so that expatriates dominate. Long-term training is being done in most countries, but this reduces short-term capability to implement projects. We also face problems of quick staff turnover, especially since the staff returning from training are sometimes approached by other organizations, particularly in those countries where there is a strong agribusiness private sector. And then there is the problem of field staff supervision, which is difficult due to distances in some cases.

5. Design of research programs. Research programs often are too ambitious, and scientists doing these programs sometimes do not receive deserved credit for their work. On methodology, we have problems with on-farm research experimental con-

trol, statistical evaluation procedures, and appropriate evaluation criteria for suitable technologies, particularly when the livestock component is included.

6. Lack of technical data or lack of component technology options to test with farmers. This is particularly true in semi-arid areas, and it seems to me that ICRISAT could play a bigger role than hitherto.

It is evident that more work needs to be done to improve the appropriateness of on-farm research models being used in eastern and southern Africa. We think that national teams must clearly define their program clients so that they can come up with appropriate recommendation domains, and also define what can be realistically achieved within a given period of time. Careful attention should be given to determine human and financial resource requirements so as not to depend excessively on donor systems or expatriates or become accustomed to high-input models that cannot be maintained in the long run.

As I said earlier, on-farm research has been in existence in Zimbabwe since 1890 when the settlers came, though only for a certain segment of farmers. Since 1980 we have tried to uplift production in the communal sector by using the infrastructure that we inherited to serve the small farmers more effectively. We found it necessary to institutionalize farming systems research, at least in my department, by creating an on-farm research unit. We have heard the view at this workshop that this is not necessary, but I am quite certain that if we hadn't created this unit, we wouldn't have been able to stimulate the on-station researchers enough to think more in this respect.

Our unit now has the function of coordinating on-farm research activities; they also work in two areas where they have been doing surveys and following the on-farm research experiments. But, specifically, their objectives are to adopt, develop, and test on farms improved crop and livestock production technologies and systems. Eventually we hope to provide information for the formulation of agricultural development policies for our communal peasant sector. The unit is autonomous and comes directly under the office of the director so that it is not seen as being linked to any particular unit of the department, crop, livestock, or other.

An interesting feature here has been the effective contribution to the unit's functions by on-station researchers. They have participated in reviews of past research and key topics of program areas, have assisted in assessing farmer situations and identifying research opportunities for a specific location. They have also participated in the designing of research trials and in some cases they are now carrying out on-station trials that have been identified for component technology development by the on-farm research unit.

The close interaction between the FSR staff and station scientists in the various units has resulted in a better understanding of farming systems philosophy and strategies and mutually beneficial working relationships. We are hoping to bring them closer together eventually. Whether we will continue to have the separate unit or whether that will be "on-station" or not, a wider perspective will be expected of farming conditions within the country.

Chairman's Summary

J.K. Coulter[1]

Four papers were presented at this session: from Indonesia, India, Ecuador, and Zimbabwe (with an African slant). The paper on Indonesia described how an FSR perspective had been incorporated in the national research program. In doing this there had been substantial collaboration with the IARCs, particularly IRRI. Three points were emphasized: the national program set the priorities; the extension system was involved from an early stage in the on-farm work; and the importance of involving policymakers in the early stages was recognized.

The paper on India described the national agricultural development objectives, including the need to increase the productivity of dryland agriculture to meet the projected population increase in the country. India has a substantial number of programs designed to evaluate the acceptance and impact of new technologies in the farmers' fields. These include operational research projects, lab-to-land programs, adaptive research programs, agricultural science centers, minikit trials, model agronomy trials, etc. It was suggested that the IARCs could help the Indian national program through the supply of new ideas and information on new technology, as well as guidance on program planning.

The paper from Ecuador reviewed the location and agroclimatic conditions of Ecuador, the range of crops that can be grown, and the impact on agriculture of its oil production. The author described the commodity-based approach as illustrated by the work on potato and the resource-based approach that served new crops such as soybean—a crop that had developed rapidly in the last two decades. For traditional cropping systems, e.g., those with maize and beans, the farmers'activities have to be analyzed and a system-cum-resource based approach is needed.

The author emphasized that FSR cannot exist as a separate program and should be part of the regular research system. Farming systems research was not new in Ecuador but it needed to be supported and it was essential to develop an attitude that was concerned with the practical aspects of agricultural development in both the educational system and in the public employee sector.

Continuing involvement of the IARCs was needed and should be utilized in a coordinated fashion. The continuing dissemination of information was an important role.

The paper from Zimbabwe described the activities of on-farm research in the region. It pointed out that on-farm research had a long history in the commercial farming sector but not in the communal lands. The paper emphasized the problems of countries where trained staff were in short supply and where there was a large gulf between what happened on research stations and what happened on farmers' fields. A large number of workshops, initiated by donors or IARCs, made heavy demands on staff time; the design of research programs was often too ambitious for the resources of

1. The World Bank, Washington, DC, USA.

those concerned to undertake. There was a need for better techniques of data collection and statistical evaluation.

The discussant, Ms Fresco, pointed out that national programs seemed to encounter fewer difficulties in integrating their FSR programs into the overall research programs; donors and IARCs seemed more intent on preserving a separate identity for FSR programs. There was a need to obtain a clearer picture of what national programs expected IARCs to deliver and for IARCs to see what they could learn from national programs. Furthermore, the national programs needed better information on what was on offer from each of the Centers.

The discussant raised the question of the homogeneity of recommendation domains. In Indonesia, for example, well defined agroecological regimes were used, but, clearly, both small and large farmers must exist in such domains; how were the problems of these addressed? The question of cropping systems as components of the overall farm and household activity was raised in the context of research approaches. Such whole systems clearly involved such considerations as labor allocation. Finally, it was pointed out that linkages between FSR and extension, for example, posed some difficult institutional problems that needed political intervention for their solution.

In the discussion that followed, five topics were considered.

1. Institutional issues, including relationships with extension systems.
2. Inter-IARC relationships and the developing-country views on these and on IARC-country relationships.
3. The role of recommendation domains.
4. Evaluation of FSR programs.
5. Relationships between subcomponents, e.g., cropping systems and the whole-farm activity.

In the discussion on institutional issues, it was clear that capacity and maturity of national research programs determined many of the institutional parameters. In some programs, the extension workers were closely involved in identification of farmers' problems and in doing on-farm trials. In others, all of the on-farm trials were done by the research system. How to integrate an FSR team into the research system and whether it should be commodity-based or run as a separate unit was a recurrent topic, the conclusion being to consider it on a case-by-case basis. The caliber of the staff doing on-farm research was regarded as important. Often junior staff were detailed to do on-farm trials, while senior staff remained behind on their stations, sometimes because they felt that they had little to offer the farmers. The result was that the feedback to the station researchers was inadequate.

In the discussion on inter-IARC and IARC-country relationships, it was pointed out that on-farm research was basically a national responsibility; the role of the IARCs was to support them in two major areas—training and the supply of information. Both implied strong IARC cooperation. However, it was also pointed out that some countries did not have the capacity to do on-farm research and that they therefore needed, at least for the time being, the intervention and help of I ARCs. It was generally agreed that the IARCs had to act in harmony in their relations with national programs, i.e., they should not be seen to be giving conflicting advice, but, on the other hand, it would be undesirable to develop a single approach to the problems.

Clearly, the diversity of the IARCs' approaches, their ability to do some things well and others not so well, provided an opportunity for the national programs to be selective.

A further factor concerning I ARCs and national program activities was the growing number of networks. These seemed to proliferate, overloading the national programs. On the other hand, asking a specific network to do too many things overloaded the network and lowered its efficiency. Nevertheless, increasing the efficiency of networks was a topic needing further examination.

On the question of recommendation domains there was discussion on how the specific objectives influenced their design. Where there was a specific crop-orientation there might be one particular design, but this need not necessarily suit other purposes well. There was obviously a desire to delineate homogeneous domains, for these could also be used for specific recommendation by, for example, the extension system.

On evaluation and impact, it was generally agreed that this was a difficult but necessary undertaking. Little progress had been achieved so far, although there was a great deal of discussion by donors on the need to evaluate this aspect of farming systems research.

Work on subcomponents within the total farm system is an area where several IARCs and other international research organizations are likely to be involved, and there was obviously need for the close cooperation of the IARCs involved. However, there were few examples so far of such programs actually in action. The IARCs were cooperating at the cropping systems level and there were a few examples of where crop- and animal-based systems were involved, but there was little activity at this stage in actual on-farm work.

Session 7

Theme Discussions

Chairman: M.H. Arnold
Convenors: D. Merrill-Sands, G.T. Castillo, and L. Fresco

Chairman's Summary

M.H. Arnold[1]

In Session 7, participants in the workshop divided into three groups to discuss:
1. the conceptual framework of FSR;
2. commonality of approach to FSR by the IARCs; and
3. interaction between NARSs and IARCs.

Each group convenor reported to the workshop in plenary session and, after discussion, consensus was reached on the following points (except where otherwise indicated).

Conceptual Framework

There was considerable sympathy with the view that what really mattered was what was actually done in farmers' fields as a consequence of farming systems research. Nevertheless, the workshop generally accepted the need for some further clarification of the underlying conceptual framework.

Most speakers saw farming systems as an approach, rather than as a distinct research discipline. It was recognized, however, that because the term "FSR" has now been widely disseminated, it would probably continue to be used. But the workshop considered that some of the misconceptions about work on farming systems could be avoided if the term FSR were replaced, at least in the literature, by the term "Farming Systems Perspective" or "Farming Systems Approach." The generic term would then probably be abbreviated to read simply "Farming Systems," for example, as a budget head, and perhaps this might be acceptable to everyone.

Within the farming systems approach, the workshop recognized that two research thrusts had evolved. Although both were directed towards similar goals, they were conceptually different. One sought to devise novel systems of managing natural resources for eventual translation into farming practice; the other sought to understand the circumstances of the resource-poor farmer in order to identify possibilities for improved technologies that might readily be integrated into an existing farming system.

The workshop discussed the various terms that had already been used to describe these two basic concepts and the work related to them. In the interests of simplicity and clarity, there was a general desire—not shared by every participant—to move towards the adoption of the following three terms:

Farming Systems Analysis—FSA,
Farming Systems Adaptive Research—FSAR,
New Farming Systems Development—NFSD.

1. Plant Breeding Institute, Cambridge, UK.

FSA would be used to describe the deep analysis of existing farming systems, including all the socioeconomic aspects. It would be limited to on-farm studies and data analysis.

FSAR would include elements of FSA but would also involve on-farm and on-station research. Feedback from on-farm research would be used as an input for the design of on-station experiments in order to develop technology closely adapted to the existing farming systems.

NFSD would eventually encompass aspects of both FSA and FSAR, but would be based initially on on-station experiments aimed at devising novel production systems, including agroforestry.

Commonality of Approach

In 1 ARCs with commodity mandates, research with a farming systems perspective is similar. Differences were noted, however, among those Centers with agroecological mandates.

Linkages between on-farm research and on-station research are being developed by all Centers. Problems have been encountered by all Centers in working with those commodities that are not included in the mandate of an existing Center. If appropriate expertise could not be found in the national systems, it has proved necessary to request support from other organizations.

The workshop supported the idea of nominating regional liaison scientists from the IARCs to foster collaboration and avoid duplication of effort. These positions could rotate among Centers. In addition, each Center should nominate an individual who could be contacted in order to obtain, or be supplied with, relevant information.

In socioeconomic research there had been a common trend to move away from post mortem evaluation towards ex ante evaluation, as well as towards a greater involvement in the diagnosis and design stages of adaptive research. In this connection, the workshop noted that NARSs were frequently lacking in a comparable capability.

There is also a common recognition among IARCs of the desirability of working closely with the extension services from the earliest stages of adaptive research, but adequate mechanisms for accomplishing this do not always exist.

In order to eliminate undesirable differences in training, the workshop agreed that countries should freely exchange training material. The idea of exchanging training staff for short periods was also suggested as worthy of serious consideration.

The workshop noted that ICRAF has an approach that is similar to that of farming systems. It has elements of NFSD as well as similarities with the commodity focus in that the tree is common to agroforestry systems. In general, however, the needs for developing agroforestry systems are more complex than those for farming systems, and, for agroforestry to be incorporated in IARC programs of FSAR, further development of methodology would be required.

The workshop noted that the exchange of information among IARCs on farming systems had started with the 1984 meeting on systems-based on-farm research, during which similarities and differences in methodology were identified. The workshop considered that the summary of this meeting contained valuable information that should be brought to the attention of all IARCs.

Interaction between NARSs and IARCs

While recognizing that NARSs and IARCs are interdependent, the workshop stressed that the success of the Centers was entirely dependent on the NARSs that constituted their most important client group. This relationship relies on mutual understanding and respect that needs to be reinforced.

The extent of interaction between Centers and NARSs is mainly dependent on two factors:

- the level of development of the NARSs, and
- the stage of refinement of new technology available from the Centers.

By defining more precisely what they require from IARCs, NARSs could have an important role in helping to harmonize the activities of different Centers in a single region. Consideration should be given to whether or not adequate institutional mechanisms in all regions for these influences to be effective. In this connection, the role of ISNAR in helping certain NARSs to define their priorities was noted, but the work of ISNAR alone should not be expected to give a complete solution to the problem.

With respect to training, the workshop identified a need for screening existing training material, with a view to developing more effective packages or modules, which could be used in national systems. In order to accomplish this, a small task force would be required, possibly comprising staff from both IARCs and NARSs. This idea was commended to TAC for further consideration.

The workshop reiterated the importance of in-country training and workshops (as distinct from workshops convened at IARCs). There was also a need for management training in FSAR. Interest was expressed in the approach to training developed by ICRA, whose expert input should also be tapped to help in classifying the training needs of NARSs.

Regarding information, the workshop identified a need to improve the availability of literature on FSAR, because many of the existing publications had limited circulation, were not reported in abstracting journals, and were not included in computerized information services. Regional networks had a role in this respect, as well as in addressing other problems relating to efficiency in on-farm research, such as the availability of appropriate seed stocks.

In addition to assisting with training and the dissemination of information, the workshop recognized the role of the IARCs in mobilizing political support for research with a farming systems perspective. Furthermore, there must be occasions when Centers should give direct support to NARSs by posting staff to work with them in specific programs. Clearly IARCs also had a role in collaborating with NARSs to monitor the impact of farming systems research.

Session 8

Synthesis and Future of FSR in the CGIAR System

Chairman: D.L. Plucknett
Rapporteurs: J. Woolley, CIAT/M. von Oppen, ICRISAT
Reviewer: E.T. York, Jr.

Farming Systems and the International Agricultural Research Centers: an Interpretative Summary

L.D. Swindale[1]

Introduction

Let me commence this summary by recalling the purpose for which this workshop has been held. The subject of farming systems research has become quite popular in recent years, particularly within the international agricultural research centers and in many of the developing countries with which the Centers work. The popularity of the subject matter has led to some confusion about the meaning of the term "Farming systems research," the scope of research undertaken in its name, and to a lesser extent, the effectiveness and relevance to agricultural development of what is being done.

The Technical Advisory Committee (TAC) to the CGIAR in its 1985 priorities paper indicates a need for increased attention by the Centers to the wise use and management of natural resources and the development of sustainable agricultural production. TAC also believes that on-farm research is an area of work done by national agricultural research systems, presumably because of its location specificity, and hence believes that input by the IARCs should decline in importance.

In 1978, TAC, finding some confusion about the nature of farming systems research and its implementation in the IARCs, requested a Stripe Review Team of John Dillon, Don Plucknett, and Guy Vallaeys to make a review and indicate what were the essential features of the subject, at least in the Centers. They came up with an excellent report, but some confusion about farming systems technology still or again exists. The Stripe Team have presented in the keynote address at this workshop an update of their earlier report which deals in part with this problem.

Farming Systems Related Research

I believe this workshop has been successful in illustrating what the IARCs and some national programs are doing in farming systems research. Virtually all Centers are involved, including two that do no biological research. The research is both commodity-based and area-based, as indicated in the titles of two sessions of the workshop, and almost all of it can be conveniently and quite simply classified into three subject-matter areas as developed at this conference and similar to those defined by Simmonds in his 1984 review. These are:

1. Farming systems analysis, i.e., the study of farming systems as they exist;

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2. Farming systems adaptive research, i.e., on-farm research with a farming systems perspective; and
3. New farming systems development.

All have to do with the efficient development of innovations and their testing—innovations as simple as a new crop variety or as complex as new farming systems for recently settled nomads.

Most Centers are undertaking studies of existing farming systems as an adjunct to and prior to their research. For this purpose they may be able to rely upon data from other sources, supplemented by additional rapid surveys. But in some cases it has proved necessary to undertake intensive and lengthy base-line studies.

The commodity-based Centers are involved in on-farm research with a farming systems perspective, i.e., on-farm research that tries to study and understand the broader implications, including policy implications, of the innovation being tested. We have had at this workshop examples of this approach from CIMMYT, CIP, IRRI and the Bean Program at CIAT. All use rather similar methods. A similar approach is used by commodity programs at Centers that are also involved with area-based farming systems research. Examples given at our workshop are the root and tuber program of IITA and the sorghum program in West Africa of ICRISAT.

Farming systems related research at the area-based Centers is primarily concerned with the development of new or improved farming systems. This applies to IITA, ICARDA, ILCA, and ICRISAT. CIAT, although predominantly a commodity-based Center, has adopted a similar approach in its tropical pastures program. Much of the farming systems development research is done at the research station, but on-farm testing of these more complex innovations is also considered necessary. CIAT has referred to the value of undertaking even the technology development in on-farm situations as well as the testing and verification.

The national agricultural research programs in Ecuador, Indonesia and Zimbabwe undertake base-line studies and on-farm, commodity-based research and have working relations with relevant Centers, CIMMYT, CIP, and IRRI, in particular. These programs are aimed at bringing production improvements into the hands of the smaller farmers. Linkages with extension services, where they existed, become something of a problem, and one reviewer considered that the programs have a rather narrow production focus.

India has a large national research program involved in area-based and commodity-based systems. It takes administrative and legislative policies into account as well as production-oriented problems.

All the activities seem to fit satisfactorily into the classification developed at this workshop. A few activities discussed here that are part of the work of Farming Systems Programs at a couple of Centers remain outside our classification. Plucknett, Dillon, and Vallaeys (this workshop) have questioned the wisdom of retaining separate farming systems units or programs. By definition, any research carried out by a farming systems program is presumably farming systems research, whether it fits the classification or not. An example might be the bacterial survey of soils being carried out by ICARDA. I have no doubt that ICARDA has good reason for carrying out this research. The problem is not the research but the name of the program in which the bacteriologists work.

But we should not strive to classify all our work in FSR into a few categories. Simmonds reminds us that too much standardization and coordination stifles creativity. The problems we are dealing with are not easy; they will require innovative solutions.

Although this summary so far has emphasized the classification of farming systems research activities, few of the Centers showed much interest in these taxonomic details. They have concentrated on explaining what they are doing and the types of results obtained. This has been much to our advantage and has enabled us to learn from each other's experience. All of us will do better farming systems related research in the future as a result of the papers that have been read and discussed here.

The Nature of Farming Systems Research

The 1978 Stripe Review report pointed out that a farming system is not simply a collection of crops and animals to which one can apply this input or that and expect immediate results. Rather, it was "a complicated, interwoven mesh of soils, plants, animals, implements, workers, other inputs and environmental influences, with the strands held and manipulated by a person called the farmer who, given his preferences and aspirations, attempts to produce output from the inputs in technology available to him. It is the farmer's unique understanding of his immediate environment, both natural and socioeconomic, that results in his farming system."

If crops research is research about crops then farming systems research, similarly, is research about farming systems. The keynote paper describes it as an approach to research which has eight interrelated objectives:

1. To understand the physical and socioeconomic environment within which agricultural production takes place.
2. To gain an understanding of the farmer in terms of his or her skills, constraints, preferences, and aspirations.
3. To comprehend and evaluate existing important farming systems, in particular the practice and performance of these systems.
4. To improve the identification of problems and opportunities for change in existing farming systems and thereby focus research on specific key aspects that limit production or farm income and their sustainability.
5. To enhance the capacity of research organizations to conduct research on priority problems of farming systems.
6. To conduct research on new or improved practices, principles, system components or subsystems within an FSR context, and to evaluate these for possible testing on farms.
7. To evaluate new or improved systems, or system components, on farms in major production areas under normal farm conditions.
8. To assist the extension, monitor the adoption, and assess the benefits of improved farming systems.

This list seems adequate to our purpose and relates well to what we have said we are doing. We freely acknowledge that in many cases we are focusing our efforts on farming subsystems, including cropping systems, rather than the system as a whole.

Farming systems research clearly requires the measurement of numerous variables, not all of which can be controlled. The statistical requirements have been touched upon only in a few papers. It is an important subject, not only to help us reduce to an essential minimum the magnitude, and hence the cost, of farming systems research, but, even more importantly, to help us determine whether we are really doing research or not.

It is easy enough to find in the workshop papers the use of the common scientific method of setting up and testing hypotheses. The general hypothesis is that the innovation being tested will succeed in solving the identified constraints. The examples used by the participants to illustrate their approach to farming systems research all give positive answers. This is not surprising with the illustrative and explanatory papers that have been developed for this workshop. But I think that there is indeed some cause for concern, both because the complex mix of parameters and variables in which we are interested are not always all easy to measure, and because of the value-driven nature of so much of farming systems research. The ICRISAT paper mentions that there is some scope for improvement in our on-farm methodology. I hope you would all agree. It is something that we should work on both individually and together—and it has been suggested that we have additional seminars and workshops.

The Necessity of Farming Systems Research

Is farming systems research necessary? I believe it is true that present-day agriculture has been developed without it. Why use it now? Our simple answer is that too much research is being done that does not benefit the target group. I do not know whether this statement is more true today than it was in the past or that it is more true in agriculture than in industry, medicine, or space. Research is a risky business. The chances of producing useful results are fairly small. It is justified because successes, though small as a percentage of the total effort, are still numerous, and many give very high rates of return on the investment made. So should we do farming systems research? Our workshop answer is a resounding "yes."

Virtually all our Centers have farming systems research activities, as do a growing number of national agricultural research programs. The list of objectives given by Plucknett, Dillon, and Vallaeys for farming systems research is also its justification, but we have several additional reasons. First, and prominently, we believe that the use of a farming systems approach will benefit the more disadvantaged farmers, farmers on marginal lands, poorly endowed farmers, small farmers and women farmers, more effectively than conventional research; i.e., there is a large equity issue involved in using the farming systems approach. CIMMYT also points out that a farming systems approach helps a farmer make short-term improvements that are preferable to longer-term improvements because of the high discount rates on investments in agricultural research. Many farmers, particularly in the rainfed areas and marginal areas where resource constraints tend to be more severe, are reluctant to adopt complex packages of practices; a farming systems approach can help overcome these barriers to adoption—although we must emphasize that the time scale will still be long.

Technologies that increase the productivity and sustainability of low-input agriculture tend to increase management input by the farmer himself and labor requirements. Such technologies are better promoted through the farming systems approach. Standard procedures of extension are largely limited to extending innovations to more progressive farmers in sole cropping using manufactured inputs. The promotion of innovations in intercropping, double cropping, residue management, and some forms of land management need the farming systems approach.

We are not entirely agreed on whether FSR is a science or an approach to research but we know, at least, that it is not a new paradigm; i.e., it does not represent the way in which all agricultural research will be done in the future. It is an approach used to provide greater benefits to certain target groups and for propagating certain types of innovations. It does not substitute for but supplements the conventional approach.

And it is not without its problems. It requires a committment to multidisciplinary activities by scientists from different disciplines, which is not always easy to obtain. ICRA is unique among our participants in concentrating its work on base-line and diagnostic studies. It has provided a number of insights into the difficulties and weaknesses involved in the farming systems approach. Poor communication and the lack of mutual respect among scientists from different disciplines are two that ICRA highlights. It has been suggested that ICRA can help us to improve our skill in using the farming systems approach.

ICRA points out, as Michael Lipton did in an earlier paper, that a farming systems approach is conservative and tends to be constrained by what the farmer already knows or can perceive. We have been reminded of this several times. The microcomputer probably would never have been developed had scientists been limited to public perceptions of what was needed in communications 40 years ago. Farming systems research also tends to make the assumption that the farmer knows best. That is not always true. The world concern for the problem of desertification reminds us also that the farmer, particularly in the poorest developing countries, but not only there, can be in conflict with the larger needs of society. ICRA and Anderson remind us that the farmer can be in conflict with his labor. Farming systems research concentrating narrowly on farmers' values or on production alone has a tendency to overlook some exogenous and endogenous constraints. On the other hand, it can get too broad to be useful.

Farming systems is probably more costly than the conventional means of disseminating research innovations in agriculture. ISNAR highlights the difficulties of managing farming systems activities and mentions the disappointing impact of some farming systems programs.

These difficulties notwithstanding, our workshop is clearly in favor of continuing research with a farming systems perspective. The positive results achieved by each Center seem to speak for themselves. The Centers are engaged in these activities because they clearly see their value and have every expectation that they will continue to do so. If CIMMYT is correct in believing that the adoption of new technology is mostly a question of assuring that recommendations fit farmers* conditions, farming systems research, and particularly on-farm research, is the way to ensure that this will happen. We believe that agricultural research for development should have a farming systems perspective. We must recognize, nevertheless, a real need to analyze the cost and effectiveness of the farming systems approach.

The Framework for Farming Systems Research

The keynote paper by Plucknett, Dillon, and Vallaeys advocates a conceptual framework for farming systems related research comprising three major elements: base-data analysis, research station studies, and on-farm studies. All are part of the system. All must be conducted, although not necessarily by the same institute, and certainly not necessarily all at the same time. Indeed, there is an implication of a sequence, of moving from one step to the next and from the last back to the first.

This is the same framework these authors advocated in their 1978 Stripe Review report. ICARDA, ICRISAT, IITA, and ILCA, the Centers that have spoken about area-based farming systems research, all use it in their work. It can apply equally well to commodity-based farming systems research. Crop improvement research fits into research station and on-farm studies but clearly not all the crop research of our Centers can be or needs to be considered as part of farming systems research. Crop improvement research is part of the farming systems cycle if, and perhaps only if, it fits into the framework; that is, if it is undertaken as a consequence of base-line studies or of previous on-farm experiments and if the improved cultivars are tested in on-farm situations. CIAT, IRRI, and the IITA paper on root and tuber crops appear to be in consonance with this idea.

The framework might be made more useful if one additional element dealing with technology design were added. As ICRA has pointed out, and as we in ICRISAT know full well, the effective utilization of base-line studies in determining the nature of research station studies is the greatest real weakness in farming systems research. There is need for a special place in this framework for the use of mathematical models and other forms of ex ante analysis, as has been pointed out by both ILCA and ICRAF.

Particularly in rainfed agriculture, ICARDA and ICRISAT find that operational research at the research station is necessary to learn the probabilities of success in relation to climatic variability. It is difficult to obtain this information on-farm, because of the many uncontrolled variables, and because it is generally difficult to maintain a program of on-farm research on the same farm or even in the same village for more than 2 or 3 years. Also, as ICRA and ICARDA point out, it may be very costly to develop technology for a single recommendation domain, if the latter is defined with any degree of rigor. Ecuador has produced a description of a recommendation domain that mentions a large "homogeneous" group of farmers, but the impression remains that we are talking about relatively small numbers in each domain. A research institute, and particularly an international research institute, must work at a higher level of generalization, which requires the development of some form of agroclimatic or agroecological stratification and, perhaps, the use of benchmark sites.

The Role of the International Agricultural Research Centers

The IARCs are only a small part of the total agricultural research effort, even in developing countries. Few of them would spend more than 20% of their total funds on farming systems related research. Thus, they can play only a small role in this field and it should be carefully chosen. The keynote paper lists 11 areas where I ARCs could be involved if or when the national agricultural systems need our help.

New farming systems development is one area in which the Centers have a comparative advantage that is shared by only a few national agricultural research centers. The new systems can include cash crops and other commodities important to the farmer, and should not be thought of as the exclusive province of the Centers with geographic or climatic mandates. Comparative advantage also applies in the agroclimatic studies needed to relate new systems to their most probable recommendation domains. On-farm research is also needed to test the technologies as they are being developed and when available for utilization. The Centers should also be involved with national agricultural research systems in developing methodologies for farming systems research because these are transferable and will lead to improvements in performance, scientific validity, and cost-effectiveness. Present methods are not satisfactory; we should encourage methodological research.

The Centers can play a major role in training for farming systems research, recognizing that there are others such as ICRA and the Farming Systems Support Program at the University of Florida that are also involved. There would be value in exchanging training materials and in understanding each other's training goals and objectives. A seminar on Training in Farming Systems Research would be worth considering.

On-farm research with a farming systems perspective even to test simple commodity innovations can be conducted only in a few places by each Center, as is pointed out by IRRI. Regional networks of countries and locations are utilized by several Centers to spread their contributions in the widest possible manner. Inter-Center, multiple-country networks merit some consideration. It is accepted that the national agricultural research systems must do most of the on-farm research both because of its location specificity and because it is often as much demonstration as it is research. But in some parts of the developing world, particularly in Africa, the current capacity of national systems to do on-farm research and participate in networks is limited, and Centers and other agencies need to assist. Some Centers feel it necessary to assume this national role until such time as farming systems can be institutionalized in the national agricultural research systems. As ISNAR points out, however, even the national systems should put only a portion of their research effort into this form of adaptive research.

In some parts of the world several Centers are involved in on-farm research in the same countries and there is an obvious need for coordination and the formation of inter-Center teams and networks. Most Centers participated in a coordination workshop on on-farm research in eastern Africa in 1984. The proposals for coordination among the Centers and with the national agricultural research systems given in the report of that workshop merit wide circulation. Ecuador reminds us, however, that coordination of agricultural research efforts within a country is the responsibility of the country itself. We agree, and ask them to exercise their right with vigor and good judgment.

I have referred in the early part of this summary to the classification, following Simmonds, developed by this workshop, which satisfactorily includes virtually all the farming systems related research we have heard about and discussed. I have also referred to the conceptual framework given by Plucknett, Dillon and Vallaeys. To me these two serve different purposes and we can gratefully accept both. The first, to tell TAC and our donors what we are doing under the heading "farming systems research"; and the second, to remind us of the steps that we must follow for the research to be done well. As Dr Gomez has put it, our strategies may differ, but our conceptual framework is the same.

I would like to take this opportunity to express my gratitude to the Chairman of TAC, who first suggested the possibility of this workshop. I believe it has given him, his colleagues in TAC, our donors, and our partners in the national agricultural research systems the information that they need to know about our farming systems research. I thank the participants for their valuable contributions and my colleagues in ICRISAT, led by Drs Kanwar, von Oppen, and Virmani, for the considerable efforts they have made to organize and conduct this workshop for us all.

Review

E.T. York, Jr[1]

Let me congratulate Dr Kanwar, his planning committee, and all workshop participants for what I think has been an excellent meeting. The quality of the papers, their commentaries, and the overall discussion have truly been outstanding.

This workshop has been particularly helpful to me in providing a better appreciation of what FSR is all about. My association with this subject is probably quite different from that of any other workshop participant. And that difference may provide a perspective that might be relevant to this discussion. Let me explain.

During the decade of the 1970s, I was involved, almost full-time, in wrestling with the bureaucracy of higher education administration—totally removed from the agricultural research arena. In the early 1980s, I decided to get out of academic administration and devote essentially full time to my primary interests—international agricultural development, with particular emphasis on agricultural research and education.

Upon making this change, I immediately began to sense some of the feelings Rip Van Winkle must have experienced upon emerging from his long sleep. I found that in the preceding 10 years something which *appeared to* be new and different had emerged

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on the international agricultural research scene—something I had barely heard of before.

I discovered that FSR was the "in" theme with much of the donor community. USAID, for example, was pouring millions of dollars into new FSR projects, and it was obviously an area of major emphasis within the CGIAR.

I immediately began to try to learn more about this "new" effort, but I had considerable difficulty in understanding what was so new and different about it all. The basic concepts and approaches seemed to be little different from those that were being used a generation ago in the USA and, I suspect, elsewhere. Let me pursue this point for a moment because I think it is quite relevant to our deliberations.

In the early 1950s, I joined the faculty of North Carolina State University and assumed the leadership of a research program to increase the yield levels of groundnuts—yield levels that had been stagnant for as long as accurate records were available.

We put together a research program that, in retrospect, incorporated all the key concepts involved in FSR as set forth in the Merrill-Sands paper, and as endorsed by Plucknett, Dillon, and Vallaeys in their keynote paper. Specifically, the program was clearly

- both farmer- and systems-oriented;
- it involved problem-solving approaches;
- it was interdisciplinary, involving agronomists, plant breeders, plant pathologists, entomologists, economists, engineers, and others;
- it involved extensive on-farm trials; and
- it provided both input from farmers in planning research and feedback to farmers following its completion.

But, before beginning the research program, we spent several months in the field visiting with extension personnel, farmers, and others, observing farming operations, getting familiar with farmers' practices, cropping patterns, etc. All of this was an attempt to better understand the problems and constraints that limited production. At the same time, we collected climatological and soils data as well as other environmental or ecological information that might have a bearing on our efforts.

Today, I assume such activities would be classified in farming systems jargon as farming systems analysis or base-data analysis. I should add, however, that these efforts involved no separate formal projects. We looked upon such work as an integral part of the planning of a research program, little different from a thorough search of the literature. It essentially involved an assessment of the environment in which we planned to conduct our research—dealing with factors that might have an impact on the research effort.

I should add that our research program also included a new farming systems development component (using the Simmonds terminology). This was in the form of a major crop systems experiment, involving various cropping sequences and a variety of management practices.

At the time the research program began, the university had no groundnut extension specialist, and research personnel, of necessity, were involved with extensive interactions with farmers. Two years later, the research results looked so promising that we employed a full-time extension groundnut specialist. He began to function as an integral part of an interdisciplinary, research/extension team, assuming increasing responsibility for maintaining continuing contacts with extension field personnel and farmers, and feeding back information to the research team on farmers' problems and needs.

Twenty years after the work had begun, average state groundnut yields had increased more than threefold with the increases directly attributable to the results of the research and extension effort.

In my opinion, what I have described was truly "research with a farming systems perspective," as we are using that term today.

I use this personal experience to illustrate a point. However, I should emphasize that in the last 30-35 years there have been similar experiences all over the USA, with essentially every commodity of economic importance. Such work has contributed to yield increases in the post-World War II era of some two-, three-, or fourfold with most agricultural commodities. Furthermore, I am sure there have been similar experiences in Canada, western Europe, and other more developed regions.

In the USA today, extension programs, closely integrated with research efforts, frequently assume much responsibility for on-farm testing and adaptive research efforts. Furthermore, with close linkages between research and extension, along with established feedback mechanisms, extension helps to insure that research continues to be "farm-oriented with a farming systems perspective." In that respect, such extension programs perform some of the functions considered to be an integral part of FSR.

Given this vital role that extension should play in this process, I have been somewhat surprised that this function has received so little attention in our discussion. As the extension function in developing countries is strengthened, especially with the addition of well trained subject-matter specialists, there will likely be a changing role for research personnel in terms of on-farm research. Such considerations need to be factored into how the IARCS approach this subject—especially in methodology development and training.

I am not an authority on Indian agriculture, but I am tremendously impressed with the advances that have been made in India over the past two to three decades. These advances have included a seven- to eightfold increase in wheat production, a threefold increase in rice production, and somewhat comparable improvements in a number of other commodities. This has been done without a major farming systems effort as such. I suspect a significant reason for this is that the strong research program in India has been complemented by an excellent extension organization with a close integration of the two functions.

Coming back to the issue of research with a farming systems perspective in the more developed nations, I was intrigued by Dr Anderson's suggestion that this was an approach that the more developed nations should adopt. It is obvious that research of this nature has been under way for many decades in some parts of the world. This was confirmed by Dr Jha of IFPRI earlier this week, when he indicated that IFPRI had found "a prevalence of research with a farming systems perspective in the earlier days of industrialized countries."

This was obviously not called FSR. But the concept or philosophy has been an integral part of the agricultural research effort in these countries for many years.

One big difference in the early efforts to which I referred, and what is being done today under the label of FSR, is that the early work had a much lower level of involvement of economists and other social scientists. I recognize fully that much more might have been accomplished had there not been that deficiency— had there been a better balance between economics and other disciplines such as agronomy. Despite this deficiency, however, the results have been quite impressive—by any measure.

In this regard, I would differ somewhat from Dr Swindale's suggestion that much of the past improvement in agriculture has been achieved without the use of FSR. It is true the FSR term or label has not been used, but the basic concepts have been employed and have made significant contributions to the advances made.

This brings me to what I think is one of the most significant points emerging from this workshop—specifically, that research with a farming systems perspective is not a new science or discipline, but rather it is a concept, an approach, a method for making research more relevant and meaningful. I agree fully with Dr Gomez that, if we accept this concept, at least some of what we call FSR (particularly on-farm research) should become such an integral part of ongoing agricultural research efforts that it would lose its label or identity—just as these concepts or approaches have never acquired such an identity in many developed countries.

The obvious question, however, and the one I have been wrestling with, is this: If farming systems is not a new or radically different concept—and I don't think it is—why has it emerged so prominently in IARC and developing-country strategies? Why is it being evangelized by some as a new religion or wave of the future?

First, let me respond by saying without equivocation that it is indeed an important concept. Furthermore, it may indeed represent a new concept or approach to many Third World countries and to the I ARCs that have a responsibility for serving these countries. I think there are two basic differences in the situations applying in developed and developing countries that have an impact on this issue.

First is the absence of effective extension programs in many developing countries, especially in Africa. Of course, there is no extension dimension in the IARCs. Their research programs have to fill a void created by the absence of close, effective extension linkages and functions.

Another reason why special attention must be given to FSR in the IARCs and national research programs of developing countries was alluded to by Dr Wessel earlier this week. He pointed to the fact that so many agricultural scientists today have little or no background in production agriculture or experience with farmers. Furthermore, their training is often in more highly specialized disciplinary areas rather than in the more applied agricultural sciences.

One reason why this is not a major concern or limitation among earlier generations of agricultural scientists is that most such scientists grew up on farms—many of them were from "resource-poor farms"—and were acutely aware of farmers' problems and needs and took these fully into account in planning and executing our research efforts.

Much of what I have said reinforces or expands on points made in Dr Swindale's paper. I am also impressed by the extent to which TAC's position on the subject, as stated in its 1985 Priorities paper, so closely parallels the general consensus that seems to be emerging from this workshop.

Let me review briefly some of the key elements of TACs treatment of the subject.

TAC's paper points out that multidisciplinary research, centered on specific commodities but aimed at improving whole production systems, has been and should continue to be the central thrust of the CGIAR. While focusing on commodities, TAC recognized that agroecological and farming systems approaches are also important elements of the programs of some Centers. Now let me quote specifically from the TAC report.

> Various types of research on farming systems have also proved to be valuable as complementary approaches to commodity research. Such research is closely related to multidisciplinary commodity research but is broader in perspective. It aims at increasing the sustainable productivity of whole-farm systems, rather than that of a commodity as a specific element within a production system.
>
> In the CG system, research on farming systems has incorporated three basic and quite distinct activities: (1) base-line data analysis for characterizing major types of farming systems with agroecological zones; (2) research station activities directed towards the development of new farming systems; and (3) farming systems adaptive research which incorporated on-farm research and the testing and fine-tuning of technologies to specific environmental and farm management conditions.
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> TAC considers that research with a farming systems perspective will continue to be useful and relevant to the Centers' work over the short to medium term. Centers are encouraged to maintain an active dialogue aimed at evaluating, improving, and harmonizing their respective approaches to farming systems research. In the long term (25 years), however, TAC considers that the respective roles of the three primary aspects of research on farming systems will vary in the System.
>
> TAC considers that base-line data collection and analysis should continue to be used in the International Centers until an adequate knowledge base is created. At greater levels of specificity, however, the responsibilities for this type of research should be taken over by national or regional research institutions.
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> The Centers should also continue to work on developing new farming systems for major agroecological zones, particularly where physical resource limitations are great and where new concepts of resource management are necessary to achieve a breakthrough in productivity as, for example, in the humid tropics. TAC sees this approach as complementing the multidisciplinary commodity approach, rather than becoming a substitute for it. TAC believes that since farming systems adaptive research, or on-farm research, is highly location-specific, it is more appropriate to the level of national, rather than international, agricultural research. The CG System should, therefore, limit its activity in this area to strengthening national systems' capacities. Centers should continue to concentrate their effort on developing research methodologies in FSAR, training national scientists in on-farm research methods, and stimulating awareness

of the benefits of this research approach which integrates the farmers' needs, priorities, and knowledge into the process of technology development. In all cases, Centers should maintain active linkages with FSAR programs in collaborating national systems as a means to channel critical feedback to the Centers' scientists in the performance of their technologies and recommended management strategies.

Let me say in closing that I have heard nothing this week that would suggest the basis for any major departures from the position taken in the TAC paper.

It seems to me that, in the final analysis, we are focusing on two major types of activities: (1) on-farm adaptive research and (2) research dealing with the development of new or improved farming systems.

I do not discount the importance of base-data analyses. But such research efforts could be looked upon as being complementary to, if not integral parts of, the other two major thrusts.

IARCs will obviously continue to be involved in on-farm research, but, given the location-specific nature of such efforts, the primary role of IARCs in this area appear to lie in working with the national programs in the development of methodology and in training. The latter role will become tremendously important.

The remaining major efforts or functions are in the area of new farming systems development. I share fully Dr Simmonds' enthusiasm for this area of activity—because such approaches do involve potentials for significant improvements, if not revolutionary advances.

I am impressed with the fact that most Centers are actively involved in research to develop new and improved farming systems. I think that, in the long term, this is an area that offers great promise and should be actively pursued.

Again let me congratulate you for an excellent workshop and thank you for the opportunity to participate.

Chairman's Summary

D.L. Plucknett[1]

I am going to be brief in my summing up.

I think we all agree that finding ways to make science more effective at the farmer's level/and to involve the farmer in that process, is a very important matter.

Secondly, one of the things that farming systems research has been accused of is being strong on good intentions but weak on analysis. Our analysis of secondary

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information does not appear to be as good as it should be, and we are perhaps not as innovative as we might be. I think we have to stress the need for such analysis, because this type of work helps IARCs to plan their research programs more efficiently, and it widens national programs' perceptions about farmers in their own communities.

Thirdly, I think effective cooperation between IARCs and national programs is a major area of concern. We have had some examples of its beneficial effects this week, supported by expressions of approval about some of the results achieved.

Fourthly, I think we need to recognize that FSR can be useful, not so much as a recipe but as a concept. However, this approach to research has always been hard to explain, not only to administrators but even to colleagues. And we should perhaps reflect that any activity that has difficulty in explaining itself to others will not long survive, or will at least be called into question. Therefore we need to define FSR and its activities more clearly. This week I think we have made a move towards clarification—not to put a straightjacket on anyone, but to insure that our concepts are correct. I believe we can now explain to others why it is that one Center does a lot of work on natural resources, while another focuses its research on-farm.

FSR, especially OFR, can have serious attendant problems. If it is done badly, it may leave scars on a farming community for years. Mistakes on experiment stations may be redeemable; but real mistakes with farmers can leave many residual difficulties. I think we therefore need to organize ourselves conceptually so that we know what it is we want to do in OFR, and then go about that work in such a way that farmers are clearly involved and the work is well done.

Fifthly, the question of cost has been raised. It seems to me that OFR can be very costly, even though some have said it need not be expensive. One has to consider on how many sites one can operate, because each site costs something. In many countries access to farms is difficult, and transport or local support may not be available. Enumerators may need training in research procedures, and there is the related question of quality control. I endorse the idea of an "effective minimum", in which costs are balanced against the operational demands that have to be met to do the work efficiently.

I think the discussions this week have been excellent and I thank each of the chairmen of each of the sessions. I enjoyed Dr.Swindale's summary and the discussion that followed; there were a lot of cogent and incisive thoughts in it that stimulated a wide-ranging discussion. Finally, I feel that this has been a successful workshop, and I am pleased to have been involved in it.

APPENDIX

Statement of the Representatives of the IARCs at the Workshop

The following statement was prepared by an informal group of representatives of IARCs[1] who participated in this workshop. The deliberations of this group were not a part of the program of the workshop, and the statement therefore does not represent an outcome of the scheduled program. However, the statement, as constituted, was deemed important and is included as a part of the record of the workshop and its attendant activities.

The group's consultation aimed at comparing and contrasting objectives, strategies, and methods in order to facilitate inter-Center understanding and cooperation, especially in working with national agricultural research and extension systems.

Clarifying the Concepts

It was agreed that the essential underlying concept is that farming systems research is an approach to agricultural research. A farming systems approach has the following characteristics:

1. Problem-solving research that explicitly recognizes the farmer and other agents in the food system as the primary clients of agricultural research systems.
2. Research that recognizes interactions between different subsystems in the farming system and which may often require a multicommodity approach.
3. Research with an interdisciplinary approach that requires close collaboration among technical scientists (physical and biological) and social scientists.

The farming systems approach aims to improve the efficiency and relevance of the agricultural research system, especially in terms of increasing the productivity and income stability of small farming households while preserving the resource base. A farming systems approach is best incorporated through complementary on-farm and on-station research, with farmers' perspectives playing an integral role in technology design and development. In a farming systems approach, on-farm research is conducted with farmer participation in order to understand existing farming systems, identify problems and research opportunities, test appropriate solutions, and monitor acceptance of improved technologies.

It was recognized that the farming systems approach is not in itself new to agricultural research. Successful research has almost always embodied the elements described above. However, because a lack of a farming systems approach has often limited the effectiveness of many research systems, it was felt that there is a need to formalize the

1. CIAT, CIMMYT, CIP, ICARDA, ICRISAT. IFPRI, IITA, ILCA, IRRI, and ISNAR.

inclusion of a farming systems approach as defined above in the programs of both national and international research systems.

On-farm research should largely be implemented through national systems with effective feedback mechanisms to on-station research in national and international research institutes. International Centers often have a comparative advantage in developing methods and in training for incorporating a farming systems approach in national programs. International Centers should also continue to have direct involvement in implementing some on-farm research programs in order to refine methods and to ensure that scientists at International Centers themselves are exposed to farmer problems.

It was agreed that IARCs with a mandate for a broad agroecological environment may experiment with farming systems that differ radically from existing farmer practices, in order to explore the *potential* productivity and stability of the resource base in that environment. Such research need not always have a farming systems approach, but is often an important supporting research activity with distinct objectives.

Impacts and Lessons from the Past

A farming systems approach is now being adopted and incorporated by many research systems. This is reflected in increased contact between scientists and farmers, a greater sensitivity of scientists to the complexities of small farmer systems and changes in attitudes of scientists toward addressing farmer problems (both in national and international research systems). Results of on-farm research have been particularly valuable in feeding back information to on-station research and changing priorities accordingly. At the same time, as the farming systems approach matures in many programs, there is growing evidence of acceptance of technologies being generated.

Experiences gained over the last 10 years have also provided guidelines for incorporating a farming systems approach in research systems. These include: a greater need to cement linkages between on-farm research and on-station research with the same scientists involved in both types of research activities; the need to have clearly defined objectives and terms for the various research activities that comprise a farming systems approach; the need for commitment and continuity of personnel for effective research; and, finally, realistic expectations that several years are needed before research will have an impact on farmers.

Looking to the future, the group sees continued emphasis in the IARCs on training and support for incorporating the farming systems approach in national programs. Considerable work is needed to further develop methods for on- farm research and, especially, to formalize linkages of on-farm research with on-station research and with policy analysis. The IARCs should seek to improve collaboration among themselves, especially in sharing information on methods and in coordinating work with national programs and in jointly conducting training programs. It was noted that collaboration has been increasing and that this has been beneficial to both IARCs and national programs.

Organization and Participants

Steering Committee

The following members of this committee met at the Taj Palace Hotel, New Delhi, on 28 Feb 1985, to formulate a program for the workshop, and to decide the venue, dates, duration, and the number of participants.

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Acronyms

AFRENA	Agroforestry Research Network for Africa
AVRDC	Asian Vegetable Research and Development Center
BDA	base-data analysis
CARDI	Caribbean Agricultural Research and Development Institute (Trinidad)
CATIE	Centro Agron6mico Tropical de Investigaci6n y Enseftanza (Costa Rica)
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CIP	Centro Internacional de la Papa
CRIFC	Central Research Institute for Food Crops (Indonesia)
FSA	farming systems analysis
FSAR	farming systems adaptive research
FSP	farming systems perspective
FSR	farming systems research
FSSP	Farming Systems Support Project
IARC	International Agricultural Research Center
IBSRAM	International Board for Soil Research and Management
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRA	International Course for development-oriented Research in Agri-culture (The Netherlands)
ICRAF	International Council for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre (Canada)
IFDC	International Fertilizer Development Center
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Center for Africa
INAT	Institut national d'assistance technique (Belgium)
INRAT	Institut national de la recherche agronomique (Tunis)
IPM	integrated pest management
IRAT	Institut de recherches agronomiques tropicales et des cultures vivrieres (France)
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
LDC	less-developed country
NARS	National Agricultural Research System
NFSD	new farming systems development
OFR	on-farm research
OFS	on-farm studies
OFVT	on-farm verification trials
OSR	on-station research

RFSP	research with a farming systems perspective
RSS	research station studies
R&D	research and development
SAPRAD	Southeast Asian Program for Potato Research and Development
SAT	semi-arid tropics
TAC	Technical Advisory Committee (CGIAR)
USAID	United States Agency for International Development
WARDA	West African Rice Development Association

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