ICRISAT
Farming Systems Research

A Special Report

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
ICRISAT Patancheru P.O.
Andhra Pradesh 502 324, India

July 1983

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Foreword

The study of farming systems is not new in the discipline of agriculture. But the concept of multidisciplinary institutional research on farming systems is new, and it is still evolving.

ICRISAT was among the earliest of the international agricultural research centers to give formal recognition, in its mandate, to the need to supplement research on individual crops with research into the integration of the various components of farm productivity, in terms of stable and socioeconomically viable farming systems in the semi-arid tropics. The Farming Systems Research Program (FSRP) was the first to commence research experiments at ICRISAT in June 1972, prior to the meeting of the first Governing Board.

After 9 years of intensive research that has led to the development of what appears to be a successful technology for improved management of deep black soils (Vertisols) in India, it seemed appropriate that the FSRP should organize a special in-house review to discuss and elucidate the concepts of farming systems research in relation to the Institute's organizational framework, and the objectives and strategies proposed in the literature.

The review was held at ICRISAT in conjunction with the annual meeting of the Program Committee of ICRISAT's Governing Board in March 1981. The chairman, Dr. John Dillon, and a member, Dr. Guy Vallaeys, of the panel that made a Stripe Review in 1977 of farming systems research in the International Agricultural Research Centers on behalf of the Technical Advisory Committee of the CGIAR participated in the review. Both are now members of ICRISAT's Governing Board. The Chairman of the Board, Dr. C.F. Bentley, also participated.

Six groups of scientists from ICRISAT's Farming Systems and Economics Programs prepared working papers that were presented and critically discussed during the meeting, under the coordination of S.M. Virmani. The review was informal in nature, and achieved its objective of generating frank discussion on various facets of farming systems research, in the Institute and elsewhere. As a result of these fruitful deliberations we have sharpened our views on the nature and implications of research in this field of study in tropical agricultural development. I thank all who participated in this important meeting, and commend to a wide readership this shortened version of the proceedings.

L.D. Swindale
Director General

INTRODUCTION

S.M. Virmani

FARMING SYSTEMS RESEARCH AT ICRISAT

Farming systems research is multidisciplinary in nature and uses a whole-farm approach for improved technologies, to enhance and stabilize agricultural production in the semi-arid tropics (the SAT). The research strategy includes base-data analyses, on-center research, and on-farm research. Base-data analyses comprise the compilation and synthesis of available data for delineating homogeneous areas and for determining research priorities and strategies. On-center research aims to examine components of research that have important implications in technology development, and is primarily multidisciplinary in nature. On-farm research involves a variety of surveys, evaluative experiments, and yield-gap analyses, and is designed to complement on-center research.

The need for interaction with other programs at ICRISAT and with national programs has been highlighted. Complementarity in the research strategies of ICRISAT's Farming Systems Research Program (FSRP) and national program researches, and the relevance of methodology development and training in this regard, have been emphasized. Research organizational structures should allow flexibility and should encourage team research.

CENTER-BASED RESEARCH, STRUCTURE, AND INTEGRATION OF FARMING SYSTEMS RESEARCH TECHNOLOGY

This paper attempts first to define clearly the distinction between basic and applied research within the context of farming systems research. It suggests the need for a balance between basic and applied research and argues that basic research should not be sacrificed because of the temptation to achieve short-term goals.

It suggests that farming systems research is a continuum in which five stages, or "activities," may be identified: (1) base-data analysis, (2) single-component research, (3) multicomponent research, (4) integrated operational research, and (5) on-farm research. For the on-center activities (1 to 4 above), proposals are made of the required balance of basic and applied research and the distribution of resources to farming systems research.

The study group suggests that, for the better integration of research between disciplines, or subprograms, the creation of a few disciplinary groups should be considered. It recommends the formation of coordinating units to ensure the proper functioning of multicomponent and integrated operational research activities. The purpose and structure of integrated operational research (an activity not very clearly defined previously within ICRISAT's FSRP) are described in some detail.

THE NEED FOR RESEARCH AT BENCHMARKS

The need for benchmark sites, which has been stressed in past reviews of farming systems research in the SAT, arises especially because wide variations in soils and climate create sufficient diversity of environments for crop growth that simulation modeling is not yet able adequately to predict crop performance. However, the analogue method is an effective tool for the transfer of empirical research results from an experimental site to other parts of the region; this approach requires that the experimental sites be carefully selected benchmarks representative of appropriate soil-agroclimatic units in the region. A three-tier system of benchmark sites (primary, secondary, and tertiary) is discussed for the generation and transfer of farming systems research technologies in the SAT.

The criteria used for the selection of benchmark sites—and the environments that these serve—have received far too little attention in previous research, although it is generally recognized that soil and/or agroclimatic factors are the major causes of location-specificity in research results. In the past, benchmark selection has been hindered by the general lack of satisfactory resource inventories and classification systems. An appropriate classification system is available for pedology, but a similar system for agroclimatology is still under development. Inventories of both soils and climate have been inadequate, but are rapidly improving. Some further research is needed to determine the optimum size of soil-agroclimatic units for the transfer of farming systems component research and new technologies.

COLLABORATIVE RESEARCH WITH NATIONAL RESEARCH CENTERS

Since farming systems research tends to be highly location-specific, collaborative research at various locations is required for testing and fine-tuning components as well as systems. Past reports have strongly recommended the identification of benchmark locations and the conduct of collaborative research with scientists from national programs. Once such benchmark locations are identified, there is a particular need to convene meetings of ICRISAT scientists with those of other institutions to identify the problems and jointly to suggest suitable collaborative research topics and procedures for various regions. It is important that research be conducted in collaboration with several national and regional institutions rather than with any single organization, although the total number of centers where research efforts can be concentrated should be limited. The potential for collaborative work with agricultural universities should receive special attention in the future. For collaborative research in Africa and in other SAT regions, greater participation by ICRISAT scientists is required because national programs in those countries are not as developed as those in India.

ON-FARM RESEARCH

On-farm research plays an important role in farming systems research at

ICRISAT. Without on-farm research the vision emanating from a focus on farming systems would be seriously impaired, because scientists would have little assurance that identified research priorities address actual on-farm problems, that proposed solutions measure up to expectations under farmers' conditions, and that released technologies have potential for rapid adoption.

ICRISAT on-farm research should embrace six objectives.

1. To study existing farming systems to identify constraints to production and thus indicate potential research areas.

2. To test technology options under "real-world" situations.

3. To monitor the adoption and assess the impact of recommended technologies.

4. To develop and evaluate methodologies and approaches to on-farm research for training programs.

5. To provide a means for technology transfer through national programs.

6. To channel the exchange of information between farmers and researchers.

In order to satisfy these objectives, ICRISAT on-farm research should be directly involved in base-data collection and analyses; diagnostic and exploratory research; technology testing; adoption and impact assessments; and training programs.

Successful on-farm research requires a close working relationship between ICRISAT, farmers, and national programs. It should be designed to complement and support on-station research at ICRISAT Center and at benchmark/cooperative research locations. The same scientists who carry out on-station research must be responsible for the design, execution, and management of on-farm research. Even so, there is a definite need to coordinate on-farm research, and a principal scientist should lead such a coordinating unit.

INTEGRATION OF SCIENTIFIC RESEARCH ACTIVITY

The question of integration of scientific research activity in farming systems research is discussed in relation to the following considerations: the need and relevance of multidisciplinary research projects; problems associated with the integration of farming systems research at ICRISAT Center; and problems associated with the integration of farming systems research between Center and benchmark locations. Farming systems research provides a means by which multidisciplinary teams of workers can develop improved technology for small farmers of the SAT. The multidisciplinary approach must emphasize the question <u>why</u>, instead of merely recording <u>what</u> in order to overcome the site- and season-specific nature of research in the SAT and to utilize resources efficiently. Difficulties of the farming systems research approach are examined. Problems associated with leadership, the functioning of the FSRP coordinating unit in the establishment of goals and priorities, the relation

of farming systems research at ICRISAT to that at African benchmark locations, and the commitment of researchers to the team approach are discussed; suggestions are advanced for the solution of these problems.

OBJECTIVES AND ORGANIZATION

S.M. Virmani

RELEVANCE OF FARMING SYSTEMS RESEARCH TO ICRISAT

Farming systems research, by definition, is holistic and multi- and interdisciplinary.

The need for such research is universally recognized in the context of modern agriculture. It is particularly important for the SAT, where farming systems are diversified, crop yields are low and unstable, and the ecological balance is fragile. Opinions, however, are sharply divided on the activities that farming systems research should encompass, the strategy involved, and the way it should be conducted.

HIERARCHY OF SCIENTIFIC DISCIPLINES

To be useful, such research must draw upon expertise from an array of sciences. The scientists in each of these disciplines are trained to address specific research needs. The integration of these scientific efforts and questions related to the balance between basic and applied research are major problems. Some see merit in farming systems primarily as an applied arm of an agricultural research institution; meanwhile scientists working in ICRISAT's FSRP are concerned with the question of peer recognition and career development. While review teams such as the TAC Stripe Review recommended that the FSRP should publish its findings in refereed international journals, an occasional visitor views the conduct of discipline-oriented research as contradictory to the mission-oriented approach of the Program.

PHILOSOPHIC PROBLEM OF REDUCING CONTINUA

The semi-arid tropics, our mandate region, exhibit continuous variations in time and space; some of these are more or less regular: for example, climatic elements, soils, and crops. The "agroclimate" is a collection of contiguous "environments," each of which has specific characteristics lying within. An infinity of factorial combinations can, in principle, be created. How can one conceptually solve the problem of reducing a continuum into a finite number of discrete "environments"? Are boundaries inherently artificial in any such system? Should we be pioneering new research methodologies to cope with the marked location-specificity of technologies in the SAT?

methodologies to cope with the marked location-specifity of technologies in the SAT?

MULTIFACETED RESEARCH

Farming systems research is conducted at ICRISAT research centers, on-farm, in collaboration with national programs, and over areas ranging in size from small experimental plots to operational-sized watersheds. Should on-farm work be a mandate of an international institute? How much time of a given scientific group should be allocated to these various activities? Would it be advisable to have specialist groups in the program assigned separate responsibilities for these activities? How systematic should we be? Is there always a need to integrate research findings into newly designed ICRISAT farming systems?

ANALOGY FROM INDUSTRY

Industrial organizations have large research and development departments focused primarily on producing a marketable finished product. We learn that the International Fertilizer Development Center (IFDC) is following targeted research oriented towards the final products. Principles, research methodologies, etc., are by-products. Should we take this approach in evolving a final package of improved technology?

FUTURE OUTLOOK

Times are changing. A detailed bibliographic survey conducted by the International Institute of Tropical Agriculture on multicomponent agricultural research published over the past few years in refereed international journals showed a marked trend towards acceptance of such research effort. Perhaps farming systems research at ICRISAT is ahead of its time. After all we were one of the first of the CGIAR institutes to have farming systems research included in our mandate.

It was with this background that the present review has been called for. The review is an in-house institute activity aimed at conceptual soul-searching. It attempts to describe the present focus of ICRISAT's on-center on-farm farming systems research. It shows how the FSRP, which is only one element in the whole complex, has evolved, and how it relates to the other research programs in the institute and to national research activities. It considers factors to be taken into account in developing a future strategy for farming systems research. These include structure, organization, and approaches to the setting of priorities. The present organizational chart of the FSRP is shown in Figure 1.

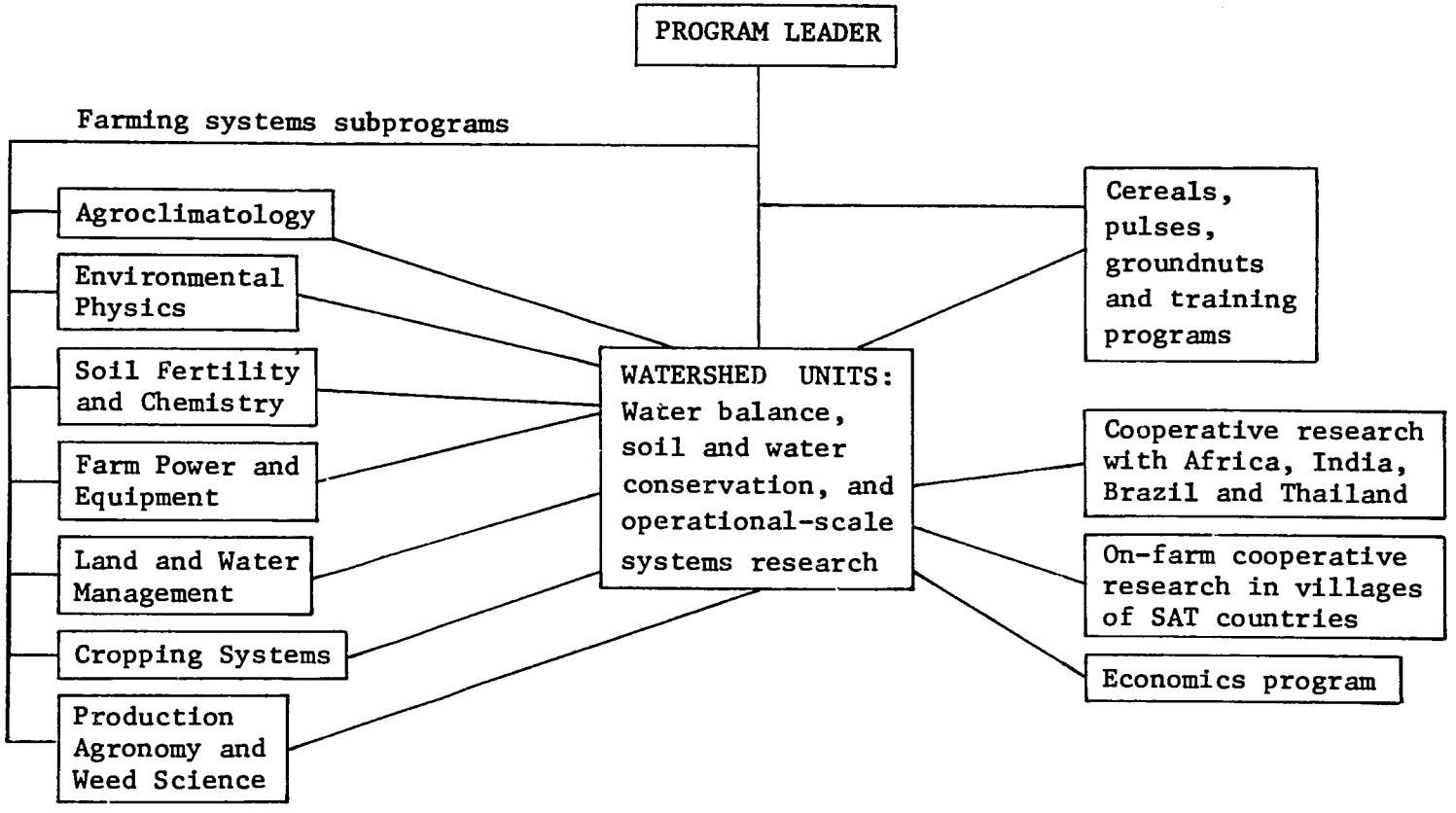

Figure 1. Organizational chart of the Farming Systems Research Program (FSRP) at ICRISAT.

Six working committees were assembled to review various aspects of farming systems research at ICRISAT.

1. Farming systems research at ICRISAT: The needs, objectives, and strategy. S.M. Virmani, B.C.G. Gunasekara, J.G. Ryan, T.S. Walker, T.J. Rego, V.S. Doherty, M. Natarajan, and V.S. Bhatnagar.

This committee discussed and prepared a working paper based on various documents such as the Stripe Review, the Quinquennial Review, and consultants' reports. The committee analyzed important aspects of ICRISAT's farming systems research and drafted a number of broad recommendations on objectives, strategy, activities, structure, and relationships with national programs.

2. Center-based research, structure, and integration of farming systems research technology. R.W. Willey, A.K.S. Huda, F.P. Huibers, S.V.R. Shetty, K.L. Srivastava, and K.L. Sahrawat.

This committee discussed and prepared a working paper on the need for center-based research. It reviewed the present structure of the FSRP. Particular attention was given to the relevance of operational research. It also analyzed the balance between applied and basic research in different areas of farming systems research.

3. Need for research at benchmarks. J.R. Burford, R.K. Bansal, S.M. Miranda, S.J. Reddy, and M.R. Rao.

This committee discussed problems associated with location-specificity of farming systems research technology, and discussed the need for research at benchmark locations. The group identified areas of research that should be conducted at benchmark locations vis-à-vis center-based research and gave particular attention to the criteria for selecting benchmarks.

4. Collaborative research with national research centers. S.M. Miranda, Sardar Singh, M.C. Klaij, M.S. Reddy, and J. Hari Krishna.

This committee looked into the question of critical balance between ICRISAT research based at centers and that based at benchmark locations and between collaborative research with national research programs and with other institutions. It also outlined areas of collaboration in farming systems research.

5. On-farm research. G.E. Thierstein, P. Pathak, J.G. Ryan, T.S. Walker, O.P. Singhal, and S.V.R. Shetty.

The group prepared a working paper on the need and relevance of on-farm research for farming systems research at ICRISAT. The committee recognized

the leading role on-farm research can play in providing information to shape ICRISAT research priorities.

6. Integration of scientific research activity. J.T. Moraghan, C.N. Floyd, V.V.N. Murthy, and M.V.K. Sivakumar.

This committee examined the problems associated with the integration of farming systems research on-center and between centers and benchmark locations in different disciplines. The group noted that such research covers a broad subject area with a relatively undefined boundary within agricultural research as a whole.

The committee discussed questions on omnibus multidisciplinary research projects—the need for such projects and their relevance and desirability in relation to farming systems research at ICRISAT Center. Some attention was also given to evolving procedures for encouraging team research.

The working papers prepared by the six groups of farming systems research scientists are given in later sections of this publication. No efforts have been made to unify the six reports; each presents the collaborative view of the concerned committee on the topic assigned to it.

SUMMARY AND RECOMMENDATIONS

INTRODUCTION

Farming systems research is a relatively new area; thus it is subject to constant review. ICRISAT—as one of the first of the IARCs to recognize such research formally in its mandate—periodically reviews the objectives, organization, and strategy of the FSRP, which has evolved over the last 8 years.

This special in-house review considered what new directions the Program should take and what priorities should be set for future research. Scientists from ICRISAT Center and the West African program discussed these topics and related questions of organization with members of ICRISAT's Governing Board, the Director-General, and the Directors of Research and International Cooperation. Six working groups prepared papers as a basis for discussion. We present here a summary of each working paper and a precis of the major conclusions reached during the discussions.

1. FARMING SYSTEMS RESEARCH AT ICRISAT: THE NEEDS, OBJECTIVES, AND STRATEGIES

This committee defined the concept of farming systems research, emphasizing its multidisciplinary nature and holistic approach to the development of

improved technology. It discussed the research strategies from the point of view of base-data analyses, on-center research, and on-farm research. The need for interaction with other programs at ICRISAT and with national programs was highlighted.

Major Conclusions

a. It was recommended that the following changes be made in the second and third mandate statements of ICRISAT.

   - 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.

   - 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.

b. On-farm research is a legitimate function of ICRISAT's FSRP. It should, as far as possible, be conducted in collaboration with national programs.

c. ICRISAT's FSRP should explicitly recognize the importance of agroforestry, pastures, and livestock production, where relevant, in farming systems.

d. One of the strategies in farming systems research at ICRISAT should be to incorporate a problem-oriented approach involving multidisciplinary teams of researchers drawn from all programs to focus on well-defined subject matter areas of high priority in the attainment of ICRISAT's objectives.

e. Flexibility in the organizational structure of ICRISAT's FSRP should be emphasized.

2. CENTER-BASED RESEARCH, STRUCTURE, AND INTEGRATION OF FARMING SYSTEMS RESEARCH TECHNOLOGY

The committee reviewed the present structure of the FSRP, particularly as it related to on-center activities. It examined the relevance of operational research at the ICRISAT Center and the balance between applied and basic research.

Major Conclusions

a. Research in the FSRP should be problem-oriented, and, where basic research is indicated as necessary for the achievement of applied research objectives, it may be conducted. However, basic research must contribute to the attainment of objectives of farming systems research, mainly in terms of the development of improved farming systems to increase and stabilize food production.

b. Where desirable and relevant, prospective technologies should be tested in an operational research framework on-center before being tested on farms. It was recognized that this may not be required in all instances.

c. The proportionate allocation of time and resources to base-data analysis, on-center research, and on-farm research will depend on the stage of development of such research and the semi-arid tropical region in which it is being conducted.

d. Farming systems research should start and end with the farmer and his household. This emphasizes the need for a strong on-farm research program at ICRISAT.

e. ICRISAT is involved with the development of technologies that will find their way into improved farming systems. Hence it is necessary for ICRISAT's FSRP to conduct on-farm tests at representative benchmark locations to determine whether the principles developed in center-based research can lead to viable improvements in farming systems.

f. There was some question as to whether it was desirable to organize the FSRP at ICRISAT into structured working groups as illustrated in Figure 1 of the working paper.

3. NEED FOR RESEARCH AT BENCHMARKS

This committee discussed problems associated with the location-specificity of farming systems research technology and stressed the need for research at benchmark locations. A three-tier system of benchmark sites (primary, secondary, and tertiary) was discussed. Areas of research that should receive attention at benchmark locations vis-à-vis center-based research were identified. Criteria to be used for the selection of benchmark locations were also discussed.

Major Conclusions

a. There was general agreement on the notion of primary benchmark locations. However, the group appreciated the difficulties of using only soil and climatic classifications for determining the location of primary benchmarks. It was considered desirable to incorporate biological (pests, diseases) and socioeconomic parameters in the characterization of benchmark locations.

b. The relevance of the toposequence concept in the formulation of benchmark concepts was extensively discussed. It was felt that this requires further consideration.

c. There was no consensus on the necessity for a three-tier system of benchmark sites or on the mode of selecting nonprimary benchmark locations. Arguments for and against selection of several heterogenous sites at the secondary level were put forward.

d. It was felt that to some extent it was more relevant to select problems for research prior to selecting the benchmark research sites.

e. The farming systems and crop improvement programs in ICRISAT should utilize similar methodologies for classifying agroclimatic regions for the conduct of their research activities.

4. COLLABORATIVE RESEARCH WITH NATIONAL RESEARCH CENTERS

This committee examined the question of the critical balance between research on-center and at benchmark locations in collaboration with national programs. Suggestions were made for rationalizing the current array of collaborative research projects in farming systems research in India. Strategies for the future conduct of collaborative research with national programs were also outlined.

Major Conclusions

a. It was stressed that research should, if possible, be conducted in collaboration with a number of national and regional institutions rather than with any single organization.

b. There are several advantages in conducting collaborative research with agricultural universities. As these institutions are responsible for both training and extension, the impact of collaboration can extend beyond research and technology development.

c. It was emphasized that, in designing proposals for collaborative research, scientists from national programs should be involved right from the beginning.

5. ON-FARM RESEARCH

The need, relevance, objectives, and strategies for the conduct of on-farm research were outlined by this group.

Major Conclusions

a. The key role that on-farm research plays in providing information to shape priorities means that ICRISAT should have a strong program of on-farm research coordinated by an experienced principal scientist.

b. National programs should be involved, particularly at the stage of on-farm testing of prospective technologies.

c. It was recognized that ICRISAT scientists must have direct access to on-farm locations when conducting exploratory or diagnostic research.

d. It is not necessary that all prospective technologies emanating from

on-center research go through operational research testing at research stations prior to on-farm testing.

e. There should not be an excessive concentration on adoption studies. These should only be conducted with the aim of generating feedback into the research programs and of evaluating the payoffs from adoption of technologies generated by ICRISAT.

6. INTEGRATION OF SCIENTIFIC RESEARCH ACTIVITIES

This committee examined the problems associated with the integration of farming systems research on-center and between center and benchmark locations in different disciplines. Questions related to the coordination and management structure of ICRISAT's FSRP were addressed.

Major Conclusions

a. A coordination group should be formed for the conduct of farming systems research at ICRISAT. This should involve scientists from the farming systems, economics, and crop improvement programs. This coordinating group would identify high-priority research problems and assemble multidisciplinary teams to address them.

b. There should not be excessive compartmentalization of farming systems research at ICRISAT along disciplinary lines. This could lead to difficulties in implementing the problem-oriented approach that is suggested throughout this review.

c. Whatever organizational changes are agreed upon as a result of this review, they should be implemented with due care and at a pace compatible with other associated changes, such as budgetary procedures.

d. The suggestions for changes in organizational structure contained in the various committee reports should be discussed further before decisions are made.

e. Suggestions for improving the working relationships between farming systems research activities in Africa and India were made. There was a general concern about this question, and it requires more discussions to ensure that relationships are improved.

f. There is a need for a much closer working relationship between the crop improvement and farming systems programs, both in India and in Africa.

g. Modeling is an important component of farming systems research at ICRISAT. It enables research results to be extrapolated and assists in the determination of research priorities. Examination of the extent of possible duplication involved in current modeling efforts is required. All modeling activities should have an applied research objective that directly

relates to ICRISAT's mandate. Sophisticated models should be avoided unless absolutely necessary.

h. The program leadership in the FSRP should be a permanent appointment. The program leader should not be a subprogram leader also. There was a concern that the team approach to the conduct of farming systems research was inhibited by the need for individual scientists to publish in their disciplinary journals. It was concluded that there are increasing opportunities for publication of results of multidisciplinary research. Many journals have arisen in the past several years to cater to this type of research. In addition, the reputation of in-house publications of international centers in the international professional community has considerably increased. Furthermore, there is excellent scope for ICRISAT's FSRP scientists to be leaders in the publication of research that illustrates the farming systems research approach.

FARMING SYSTEMS RESEARCH AT ICRISAT

REPORT OF WORKING GROUP 1

S.M. Virmani (Chairman)
M. Natarajan
T.J. Rego
B.C.G. Gunasekara
J.G. Ryan
T.S. Walker
V.S. Doherty
V.S. Bhatnagar (Secretary)

INTRODUCTION

Farming systems research at ICRISAT uses a whole-farm approach for improved technologies to enhance and stabilize agricultural production in the SAT. It explicitly considers the environmental complexities and constraints, to collect information essential for the continued reshaping of research priorities. It starts with base-data analyses and diagnostic research on existing farming systems and ends with an impact assessment of new technologies. It takes place at many locations--at ICRISAT Center, on farmers' fields, and at benchmark locations on national program research stations. Its final products are not only in the form of new technologies but also of principles and methodologies that improve the capacity of national agricultural research programs to generate relevant location-specific technologies.

As such, farming systems research is not a new science but a systematic approach to agricultural research and its conduct that will have impact and relevance. It does not primarily aim at moving the frontiers of fundamental knowledge but rather attempts to adapt and use readily available technologies and to generate research results that can quickly enhance agricultural productivity. Farming systems research at ICRISAT is a multidisciplinary framework for doing resource-centered, holistic research. Without farming systems research, technological development in the SAT would either be delayed or impaired, and erosion of the remaining resource base would be accentuated.

RATIONALE

In farming systems of the SAT, diversified cropping is the rule rather than the exception, ecological balance is precarious and fragile, and livestock-cropping interactions are significant and complex. Moreover, the vast majority of farmers in the SAT have limited means and can ill afford the cost of technological mistakes that do not increase agricultural production in their environment. Nor can they tolerate opportunities missed because scarce resources allocated for agricultural research in the SAT were guided by an inappropriate set of priorities.

There is need for a mechanism by which: (a) the small farmer's natural and economic environment is understood; (b) his needs and the constraints under which he works are appreciated; (c) his farming system is analyzed; (d) alternatives and improvements to his farming system are developed and evaluated under his conditions; and (e) necessary feedback is made to the research organizaton for further refinements in the system. Farming systems research has a potential to fulfill this need by increasing the effectiveness of the commodity- and discipline-oriented research programs.

ICRISAT's main objective is to increase and stabilize agricultural production through efficient use of the natural and human resources in the seasonally dry semi-arid tropics. Farming systems research is an essential ingredient in achieving this objective. By understanding the farmers' environment and the constraints influencing their decisions, a resource-centered farming systems approach complements the seed-centered, commodity-oriented programs by sharpening the problem identification, shortening the gestation period for agricultural research, and improving the chances for adoption of recommended technologies. The fact that ICRISAT is an international center does not mean that it can evolve improved technologies within the confines of research centers in an "upstream" manner as implied by Gilbert et al. (1980). To ensure effectiveness, ICRISAT must be directly involved in base-data analyses, on-station research, and on-farm research. Unless these three activities are included in ICRISAT's research, the benefits of a farming systems research approach will not be realized. The complexity of farming systems in the SAT and the risks that farmers face offer other major justifications for an FSRP thrust.

OBJECTIVES

Three of the four mandate statements of ICRISAT contain the basic objectives of farming systems research at ICRISAT. These are the following.

- To develop 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.

- To identify socioeconomic and other constraints to agricultural development in the semi-arid tropics and to evaluate alternative means of alleviating them through technological and institutional changes.

- To assist national and regional research programs through cooperation and support and to contribute further by sponsoring conferences, operating international training programs, and assisting extension activities.

The particular objectives of farming systems research that evolve out of the above three broad objectives are the following

1. To understand the physical, biological, and socioeconomic environments within which agricultural production takes place in the SAT.

2. To evaluate existing farming systems in representative or benchmark environments of the SAT to improve our understanding of the farmers, their problems, skills, constraints, preferences, and aspirations. Such information will be used to help design crop-improvement research and farming systems research strategies, thus increasing the efficiency of agricultural research.

3. To consider research on new practices, principles, system components, subsystems, or cultivars within a farming systems research context, and to evaluate these for testing at benchmark and on-farm locations. In the design stage, interactions between prospective technologies emanating from farming systems and crop improvement research and between these technologies and the environment should be considered in order to improve the viability of ICRISAT projects and to maintain and enhance the agricultural productivity of the SAT. Likewise, farming systems research must ensure that the technologies developed are consistent with government policy objectives.

4. To evaluate prospective technologies on farms in identified priority regions and to facilitate the essential linkages between research, extension, infrastructural support systems, and development agencies.

5. To monitor the adoption of new technologies emanating from farming systems research, assess their consequences, and derive implications for future crop-improvement research and farming systems research priorities and strategies.

6. To develop suitable methodologies to achieve these objectives and to use them as a basis for training national program scientists in the concept and practice of farming systems research.

STRATEGY

Farming systems research at ICRISAT should have three broad activities: (a) base-data analyses, (2) on-station research, and (3) on-farm research. The concept of farming systems research should be embraced by all ICRISAT programs, including the crop improvement, economics, and training programs. It is not the exclusive purview of the FSRP of ICRISAT.

Base-data analyses involve compilation and synthesis of secondary and, where necessary, primary data on the SAT, aimed at delineating relatively homogenous areas for regionally focused research, to aid in determining research priorities and strategies. As far as possible, the methodologies and analyses already available in agencies such as CSIRO, COPR, FAO, ICAR, IRAT, ORSTOM, USDA, and WMO should be utilized, except where new approaches are required. Extensive critical and definitive reviews of literature on research topics of major concern to ICRISAT should form part of the base-data analysis function. These activities are envisaged as a continuing part of ICRISAT's farming systems research.

On-station studies at ICRISAT Center, benchmark sites, and cooperative research sites will primarily involve component research. A major "operational research" phase is not to be part of on-station studies but is to be included in on-farm research. However, multidisciplinary and interdisciplinary research will be strongly encouraged in on-station activities. Field experimentation, simulation, and modeling are all included under this heading.

On-farm research must be a legitimate function of ICRISAT's farming systems research. Without this, the efficacy of base-data analyses and on-station research would be in question. On-farm research should involve a combination of reconnaissance or exploratory surveys, continuing normal surveys, diagnostic experiments, evaluative experiments, monitoring of technology adoption and constraints thereto, and evaluation of the consequences of adoption, including yield-gap analysis. The precise emphasis on these elements will depend upon the geographical region and the stage at which farming systems research is at any point in time. There is considerable merit in using the same carefully selected on-farm sites for all these phases, as has been done in ICRISAT's village-level studies in India. On-farm research should be designed to complement and support on-station research at ICRISAT Center and at benchmark and/or cooperative research locations.

Crop improvement program scientists should be involved along with FSRP scientists in on-station and on-farm research phases. It is here that essential ideas and feedback will occur to help guide on-station research into areas of priority concern to farmers. These on-farm diagnostic experiments should be under the direct control of the ICRISAT scientists concerned and be actively encouraged. Evaluative experiments in on-farm contexts should include national program scientists as far as possible, but this would not be a requirement as it will depend upon the stage of development of national programs in the various SAT countries.

ICRISAT farming systems research should explicitly consider the natural resources of land, climate, people, and animals, and how they interact with cropping systems and crop cultivars to produce food. Where research into animal production systems is appropriate, it could be undertaken in cooperation with national or international agencies. The present and potential role of animals in crop production and the grain:fodder equation, as also the relations between farmers and herders, could form a component of ICRISAT's farming systems research.

A more pragmatic research focus will be oriented towards several well-defined, yet broad, research topics at the sub-system level. Specific research thrusts will be identified for concentrated research efforts from time to time, based on accumulated experience and emerging problems and constraints. For example, drawing on recent experience, it is planned that considerable effort will be devoted in the next 5 years to the deep Vertisol regions of central India, where rainfall is high and assured but where rainy-season fallowing is practiced. Criteria for selection of research topics include complementarity with research in national programs and with ICRISAT's crop improvement programs.

Farming systems research will be designed so that the data obtained and the observations made can be linked to other related research. This would require collection of minimum data sets for each of the experiments, e.g., Nix's approach (1977). Such an effort would also facilitate development of computer-based models of crop-production systems under diverse environments.

The strategy will involve a major shift from single-component research to problem-oriented, multicomponent, multidisciplinary research at ICRISAT Center. Well-designed multidisciplinary field-scale experiments will be encouraged.

While flexibility will remain the key word in organizational structure of ICRISAT's FSRP, a multidisciplinary team approach is necessary. These projects primarily address well-defined research thrusts/subjects and are viewed as ends in themselves; researchers are not compelled to reintegrate their results into newly developed farming systems. A more pragmatic research focus encourages a two-way flow of information between farming systems and crop improvement research. This approach does not sacrifice a cohesive research effort, but diversifies the research portfolio into subsystems, so that the FSRP is not wholly committed to one overriding research endeavor.

FARMING SYSTEMS RESEARCH AT ICRISAT AND NATIONAL PROGRAMS

Farming systems research is recognized as a relatively young concept, and both national and international programs are still evolving their approaches, strategies, and methodologies. Hence, if ICRISAT is to succeed in developing viable technologies and, in the process, frame materials suitable for inclusion in training programs, it must have a full farming systems research thrust. Research at both ICRISAT and national programs should include the three basic components outlined above; namely, base-data analyses, on-center research, and on-farm research. The exclusion of one component, such as on-farm research, effectively confines both national programs and ICRISAT to the status quo in terms of methodology for that component and thus inhibits technology development.

In principle, farming systems research at ICRISAT should focus on regions and their common problems rather than be involved in location-specific research. National programs should be primarily responsible for the latter. The differentiation of responsibilities between ICRISAT and national programs should not be strictly on the basis of relative emphasis on base-data analyses, on-station research, and on-farm research, but also on the types of problems they address and their regional versus location-specific orientation. Their roles should always be complementary.

As farming systems research concepts mature, ICRISAT's role may shift towards the development of methodologies, with training in cooperation with national programs playing an increasing part in active farming systems research. In this manner, we will learn from the national scientists as we impart our evolving research concepts and improve on the approach of all concerned. Training should also benefit national programs that do not have a

farming systems research program; absence of such a program does not preclude a farming systems research focus.

STRUCTURE

Viewing farming systems research as a "systematic approach to agricultural research and its conduct" implies that there must be an organizational structure flexible enough not to diminish individual initiative. Interdisciplinary and multidisciplinary interaction, which are the key elements in farming systems research, are best encouraged by purposive leadership and voluntary cooperation rather than institutionalized through structures and formalities.

Flexible procedures and mechanisms have to be developed to facilitate interdisciplinary research across ICRISAT programs on specific research projects. If farming systems research is to involve other ICRISAT programs, such as crop improvement, economics, and training, and is to cooperate with national programs, it must be conducted with a degree of coordination and control. The locus for such control and involvement at ICRISAT should be the Farming Systems Research Program.

Flexibility allows researchers to participate in all stages and components of the research. The same scientists who carry out research at ICRISAT Center should be involved in the design and execution of on-farm research experiments. Although coordination of on-farm research is definitely required, there should not be a division of responsibilities between scientists conducting on-station and on-farm experiments.

SUMMARY OF DISCUSSION--SESSION 1

Definition of Farming Systems Research

It was generally agreed that farming systems research is not a new science but a new approach. There was a suggestion, however, that its definition should be more complete than that proposed in the report of Working Group 1. One member also felt that agricultural researchers would be concerned by the idea—implied in the definition—that they were not taking a systematic approach to the conduct of research. He suggested a definition on the lines of "a systematic approach to enhance agricultural efficiency through research." There was also a suggestion that the definition should mention the farmers and the community or the nation.

Changes in ICRISAT Mandate Statements

The group supported the suggested change in the second mandate statement from "develop farming systems" to "develop improved farming systems." Such a change would not be restrictive, as it would cover both the improvement of existing systems and the development of new ones. It was pointed out that many traditional farming systems are finely honed and ecologically balanced.

However, rapid changes caused by population pressure, introduction of cash crops, etc., have changed this situation. Thus improved systems should be better adapted to maintaining ecological balance and long-term soil fertility.

In the third mandate statement of ICRISAT, the word "other" should be more specific. The word is relevant and necessary, because it covers not only technological, physical, and biological constraints but also those related to political issues and governmental policies. The group thus agreed to retain "other," with some qualification, suggesting that the statement read "physical, biological, socioeconomic, and other constraints."

Research Objectives

The six objectives listed in the report were accepted in general, with a few additional suggestions.(1) Although the small farmer of limited means would be the main concern, ICRISAT should also look for technological options to suit different resource endowments across regions and across farms within a region. (2) Farming systems research should have the flexibility to evaluate new crops introduced into a system, e.g., safflower. (3) ICRISAT efforts should be limited--in accordance with resources available--to facilitating essential linkages between research, extension, and infrastructure and to monitoring the adoption of technology developed.

Livestock Production

It was suggested that when ICRISAT is involved in a farming system in which livestock is an integral element, the mandate should accommodate the incorporation of livestock into the analysis. The need for integration of livestock and crop farming, particularly in such areas as the Sahel, and the importance of agroforestry and of pastures were also stressed.

CENTER-BASED RESEARCH, STRUCTURE, AND INTEGRATION OF FARMING SYSTEMS RESEARCH TECHNOLOGY

REPORT OF WORKING GROUP 2

R.W. Willey (Chairman)
A.K.S. Huda
K.L. Srivastava
K.L. Sahrawat (Secretary)
S.V.R. Shetty

The discussion of this committee focused on the following areas.

The balance of basic and applied research and the need for basic research at ICRISAT.

The ICRISAT farming systems research framework.

On-center research and its structure.

OBJECTIVES OF ICRISAT FARMING SYSTEMS RESEARCH

These were discussed in detail by Working Group 1 but, as a necessary background for Group 2 discussions, we very broadly outlined these objectives under three headings.

1. To develop improved and representative farming systems, or parts of systems, that are applicable to as many farmers as possible. The ultimate aim is to achieve higher and more stable production, either by modifying existing systems or by introducing new ones.

2. To develop improved methodologies and approaches in farming systems research. As an international institute, ICRISAT must play a major role in such development at all stages of research. This will generally improve the effectiveness of farming systems research by all relevant institutions (whether these are national programs, universities, or international organizations) and help to ensure the widest possible impact of ICRISAT's efforts.

3. To disseminate information about farming systems research, ICRISAT has a role to play in helping to disseminate research findings and methodologies by encouraging interaction between scientists via meetings, workshops, etc., and especially by training personnel from national programs.

THE KIND OF RESEARCH NEEDED: BASIC VERSUS APPLIED RESEARCH

By strict definition, basic research is usually regarded as that conducted purely to extend the boundaries of knowledge without any thought for practical application. By contrast, applied research must have some end application in view and is oriented to solving some practical problem. But these definitions

are applicable only in the broadest scientific sense and not within the confines of a given research area (for example, by strict definition all genuinely agricultural research must be applied research). To be meaningful for a given research area, definitions must recognize what is "basic" and "applied" within the confines of that specific area.

A further problem in trying to draw a clear distinction between basic and applied research is that any planned and properly focused research that has an end objective (e.g., as in agricultural research) is a continuum of essential and complementary stages that progressively approach the fulfillment of that objective. Thus "basic" and "applied" are often little more than convenient, but loose, terms to describe the earlier and later stages of that continuum.

Within the confines of farming systems research, basic research can be defined as the collection of necessary background data, or the elucidation of principles and processes that do not in themselves bring about a direct improvement in a farming system but that are oriented to such improvement. For example, the collection and interpretation of climatic data do not per se improve farming systems but provide an essential background for defining which systems are most likely to prove worthwhile. Similarly, the measurement of light interception in different cropping systems does not in itself improve those systems, but, by identifying areas of inefficient interception, it helps to indicate how much improvement can be brought about. By contrast, applied farming systems research can be defined as that specifically focused on actual improvement of systems and that involving some element of practical evaluation or testing of systems.

The need for a strong applied element in farming systems research is axiomatic. In contrast, the need for some element of basic research is less evident, and it was a subject of special discussion. In the opinion of the working group, basic research is an essential aspect of ICRISAT's farming systems research to provide the necessary scientific foundation from which ICRISAT can continue to meet its objectives.

Some specific reasons for conducting this basic research can be summarized.

1. To provide an ever-improving understanding of the properties, principles, and processes of the components that make up farming systems.

2. To maintain a sufficiently wide base of data, knowledge, and experience to be able to:

   a. identify the research problems whose solution is likely to give the best payoff;

   b. identify the best approaches to solving any given research problem;

   c. maintain maximum predictability and widest applicability of improved components or technologies;

d. fulfill the continuing need for modifying approaches, based on feedback information from applied research or because of changing emphasis in priority research areas.

3. As an international organization, ICRISAT should complement the research of national organizations; thus it has a role to play in carrying out that basic research which, for whatever reason, is not covered by national organizations.

4. Though it is desirable to encourage the carrying out of relevant basic research by other institutions (e.g., mentor institutions in developed countries), it should be recognized that ICRISAT often has a considerable locational advantage for conducting basic research that requires the "real-life" SAT environment; again there is often a need to conduct necessary basic research not covered by other institutions.

5. A research program that includes some basic research provides an ideal training background.

In conclusion, therefore, basic and applied research must be seen as essential and complementary stages in the farming systems research continuum, and there are some special reasons why basic research is particularly important to ICRISAT. But of course there must be an appropriate balance of basic and applied research; some suggestions on this balance are given later.

THE PRESENT FRAMEWORK

As already emphasized, farming systems research can be very simply visualized as a continuum along which there is a progressive change from the basic studies that provide the necessary scientific background to the applied studies that try to fulfill the ultimate practical objectives. In practice, of course, it is rather more complex than this. For example, it is a two-way process whereby the research at any given stage is being constantly modified in the light of information being fed back from later stages. It is also much more dynamic and flexible than the concept of a simple continuum suggests; some research areas may be advanced much more rapidly than others, and not all necessarily pass through the same intermediate stages.

Distinguishing different stages along the continuum can be done only arbitrarily but it is suggested that five activities might be usefully recognized.

1. Basic data analysis. This is the collection and analysis of necessary background information and data. It covers aspects such as on-farm surveys, the compilation of climatic and soils data, or any aspect of literature reviews and information searches.

2. Single-component research. This aims at improving relevant knowledge of the individual components. It is mainly in this area that "principles" and "processes" are elucidated. It includes such topics as characterizing soil

moisture, identifying suitable genotypes for a given cropping system, characterizing the movement of nitrogen in soils, examining the factors affecting runoff, etc.

3. Multicomponent research. This is the stage where the initial integration of components into a system, or part of a system, is examined. It includes such aspects as the integration of cropping systems with soil-fertility management. Very broadly, "multicomponent research" is synonymous with what "multidisciplinary research" is usually intended to be. The term "multicomponent" is suggested to emphasize the concept that this stage of the research is beginning to build up the system from its individual "components." While "multidisciplinary" research must by definition involve different disciplines, it does not necessarily imply an advance towards the fulfillment of a practical farming systems research objective.

4. Operational research. This is the final stage of on-center research, where systems or parts of systems are evaluated on an operational scale. It is seen as the focal point of on-center research, where all disciplines should interact. It is recognized that, for many systems or technologies, it may be appropriate to go direct to the farm for all operational testing, but for those where the practical feasibility is in doubt, operational-scale testing is an essential stage before on-farm trials. In some circumstances, these initial stages of operational testing may be more appropriately carried out at benchmark locations, or at national research stations.

5. On-farm research. This is the final evaluation of systems in the real-world situation of the farmer.

The changing emphasis from basic to applied research throughout these five activities is illustrated in Table 1. For the on-center activities, a suggested allocation of research effort is also given in Table 1, for discussion purposes.

Table 1. Suggested relative emphasis on basic and applied research at different stages, and proportion of ICRISAT efforts spent on different on-center activities, in farming systems research.

Stage of research	Relative emphasis		Relative weighting of on-center research (%)
	Basic research	Applied research	
Base-data analysis	XXXXX	X	20
Single-component research	XXXX	XX	25
Multicomponent research	XXX	XXX	25
Integrated operational research	XX	XXXX	30
On-farm research	X	XXXXX	-

ON-CENTER RESEARCH

A major problem with farming systems research is ensuring that research on individual components is integrated into appropriate systems. The following comments are made with the specific aim of facilitating this integration.

1. Subprograms and working groups. There are seven subprograms in the FSRP, and development of improved systems involves the integration of the efforts and findings of all of them. It is suggested that the formation of a few broad disciplinary working groups should be considered; this would at least facilitate integration between research areas within these groups, though the problem of integration between groups would remain. As an example, one such group might consist largely of agroclimatology and soil physics, though it is not envisioned that groups would necessarily be formed simply by combining existing subprograms but rather by combining appropriate elements, irrespective of the subprograms. Appropriate elements from other programs should also be included, e.g., socioeconomics and physiology. An alternative and more flexible arrangement would be the formation of working groups on a problem-oriented basis. These groups are not seen as administrative or budgetary divisions of the FSRP; they would probably have to be more flexible, to meet new changes in research emphasis.

2. Multicomponent research. This is an important area of research that needs greater emphasis. Ways of encouraging cooperation between scientists are discussed in more detail by Working Group 6, but some brief comments are made here. At this early stage of integration of the component research there is a need to maintain some flexibility of research structure, because individual scientists will have varying degrees of participation in different multicomponent projects. But there is a need for some structure to ensure that integration does occur. The suggested formation of a few working groups should at least facilitate the integration that is most urgently needed, i.e., the integration of related research areas within the disciplinary group. But there must also be some mechanism to ensure that multicomponent projects are identified and that the appropriate teams of scientists are involved. There would appear to be a need for a unit that could coordinate these activities.

3. Operational research. This activity is not very clearly defined in existing farming systems research, so it is discussed in some detail here. Operational research is the activity at ICRISAT Center where systems or parts of systems are evaluated, compared, and monitored to assess their feasibility on an operational scale. The basic unit of research should be large enough to study operational management and economic aspects, and to allow, where necessary, the detailed monitoring of different components. Operational research should place considerable emphasis on the integration of components or technologies from the different disciplines. It should act as an important feedback to component research, while also identifying the likely constraints in farming practice. Operational research should be conducted at a level of inputs realistic for the farmer. Some proposals for the organization of the

operational research are the following.

a. Responsibility for operational research should not be assigned to any one subprogram.

b. Though it is essential that all FSRP scientists should be involved in the operational research, it should have its own staff and resources to ensure that it is efficiently carried out. A principal scientist should be directly responsible for the operational research. Disciplines represented in the staffing should be agronomy, engineering, and economics.

c. There should be a coordinating unit that would include a representative of each FSRP subprogram. Project proposals would have to be approved and reviewed regularly.

d. Sufficient suitable land area should be available for operational research.

e. The operational group should not be seen as having a service function for other farming systems research areas (e.g., for providing cultivation, irrigations, etc.).

THE ON-CENTER RESEARCH STRUCTURE AND ORGANIZATION

A suggested structure for on-center research is outlined in Figure 2. This tries to illustrate the research continuum, as previously described, and the trend towards increasing integration of the systems components. The budgetary and administrative classification should remain subprogram-based, but the suggested structure should help towards the required interaction of disciplines within the five "activity" headings (Table 1).

The relative emphasis on basic versus applied research, and the relative weighting given to the different activities, will vary with the discipline or with the stage of research of a given project.

CONCLUSIONS OF WORKING GROUP 2 DISCUSSIONS

1. The general definitions of basic and applied research vis-à-vis farming systems research were accepted. The importance of basic research in helping to achieve farming systems research objectives was recognized. It was agreed that the balance of basic and applied research was dynamic and would change with the stage of development of a project, the nature of the project, and the SAT region.

2. The division of farming systems research into the five suggested stages or activities (i.e., base-data analysis, single-component research, multicomponent research, operational research, and on-farm research) was considered useful.

3. While it was generally considered that the present subprogram structure should remain, the formation of a few working groups was thought to be highly desirable. The consensus was that these should be flexible and organized on the basis of the particular problem(s) to be solved.

4. While it was recognized that for some systems or technologies all operational testing could be done on-farm, it was also agreed that, for those where the operational feasibility was in doubt, it was essential to first evaluate them in on-center operational research (OR). Although a strong recommendation for separate staff and resources for on-center OR had been made by Working Group 2, there were also opinions that OR should be the responsibility of the FSRP subprogram scientists.

5. The consensus was that a coordinating unit is essential to integrate all farming systems research activities.

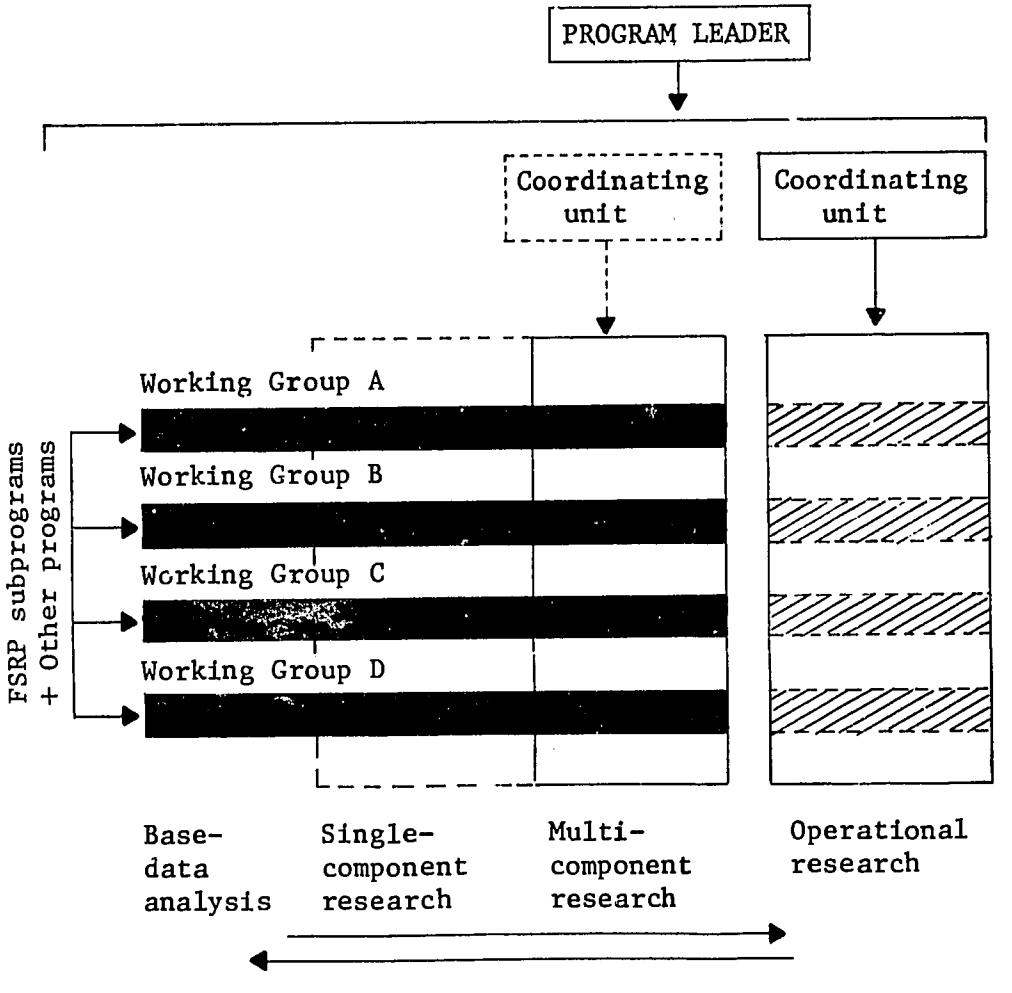

Figure 2. Diagram of proposed structure of ICRISAT's on-center farming systems research.

SUMMARY OF DISCUSSION--SESSION 2

The discussion emphasized that a proper balance should be struck between basic and applied research, the extent of each being determined by the nature of the research project and by the availability of basic infrastructure and trained scientific manpower nationally. Basic research at ICRISAT should be a means to remove any roadblocks to applied research.

There is an urgent need to integrate various components of research to find solutions to the problems faced under farmers' conditions. Though the group agreed on this point, no consensus could be reached regarding the reorganization of FSRP subprograms for the effective integration of multicomponent research. But it was felt that working/planning groups were desirable. These could be based on single disciplines at the initial stages and reconstituted on a project basis at a later stage when the various components needed to be integrated.

Operational research, particularly in Africa, could be done through cooperation with other agencies, such as IRAT and national agencies.

Research results from irrigated agriculture do not apply under dryland conditions, and we need to identify the research efforts needed for various facets of farming systems in dryland agriculture. It was suggested that pulse production should receive more emphasis in farming systems research work in Africa.

The group expressed satisfaction over the technology developed for deep Vertisols. However, priority areas need to be identified, it was felt, for farming systems research to improve crop production on Alfisols with less assured rainfall and low water-holding capacity. Supplemental irrigation was suggested as one such area for further research.

It was emphasized that on-farm research is important as pilot-plant work but that it is necessary to test the results in the real world.

RESEARCH AT BENCHMARK LOCATIONS

REPORT OF WORKING GROUP 3

J.R. Burford (Chairman)
R.K. Bansal
S.J. Reddy
M.R. Rao (Secretary)
S.M. Miranda

THE NEED FOR BENCHMARK LOCATIONS

The SAT contain a complex array of diverse environments for crop growth due both to the range of soils and climates and to the wide variations in weather, especially rainfall, that may be experienced at any one location. This environmental diversity creates special problems for agricultural research, particularly in the application of results from one experimental site to other locations.

Research resources are insufficient to attempt studies of even a small fraction of the total number of environments. Some of the diversity arises because of sensibly continuous variation in environmental characteristics across a region; temperature and rainfall are good examples. Simulation models could substantially assist in describing the effects of soil variation on crop yields; however, these models have not yet been developed to the stage where they can predict crop productivity at various locations from the basic characteristics of the location. As a result, much farming systems reseach is location-specific.

Nix (1968) has described two methods other than simulation modeling by which results at one site may be applied to other locations in a region: the site-factor and the analogue method. The site-factor approach is suitable where relationships exist between crop productivity and one or more of the key factors determining productivity, e.g., soil moisture, available nutrients, soil texture, etc. Where research results are empirical, the analogue approach is more appropriate; this involves conducting experiments at a site chosen to be representative of soils and agroclimate of that area. This is known as a benchmark site. If the benchmark site has been correctly selected, then the research results may be fairly well applicable to areas with similar soils and agroclimate in the region. Empirical approaches involve a heavy input of resources, especially in the SAT, where experiments may need to be conducted for several years to ensure that they experience a range of seasonal conditions. The selection of benchmark sites therefore requires critical attention to ensure that each accurately represents an agricultural area and serves as large as area as possible; however, these aspects have so far received little emphasis, despite the need for benchmark sites stressed by others (Norman and Wright 1975; Dillon et al. 1978; Evans et al. 1978).

BENCHMARKS

The term benchmark originiated as a surveying term to describe a reference or

datum point, especially for elevation. Its use has spread so that it is now synonymous with a reference or standard. However, in agricultural research, there has been little attempt to define what is meant by the term "benchmark site." There is considerable variation in the use of the term and in the nature of the sites used as benchmarks. Four examples can be given.

1. Benchmark villages. The Economics Program at ICRISAT is conducting socioeconomic surveys in a number of villages, selected to be representative of a major cropping area. Some selection criteria used were: village size (population), major crops, general agroclimate, and soils.

2. Ecological-zone centers. In West Africa several broad ecological zones have been identified, mainly on the basis of agroclimate, especially rainfall. Two of these zones are of particular interest to ICRISAT, because of the strong crop orientation of our mandate: the sub-Sahelian zone, in which the rainfall is marginal to moderate for cropping, and millet is the major cereal, and the Sudanian zone, in which the rainfall is higher and more assured, and sorghum is the major cereal. Sadoré, near Naimey in Niger, and Kamboinsé in Upper Volta, have been designated as benchmark centers for these regions.

3. Benchmark locations for the FSRP at ICRISAT. The Norman and Wright (1975) report recommended that the FSRP establish additional benchmark locations in India to provide more extremes in environmental conditions than are provided by ICRISAT Center. The suggested criteria for these locations were: Vertisols under low rainfall (500 mm/yr), Vertisols under high rainfall (1000 mm/yr), and an Alfisol under low rainfall (500 mm/yr); these complement the medium rainfall (750 mm/yr) locations for Vertisols and Alfisols at ICRISAT Center.

4. Benchmark Soils Project (BSP). The BSP has been conducting experiments for some time to test the hypothesis that the soil family, a classification unit in the fifth tier of subdivision in the US Soil Taxonomy, provides a reasonably homogenous soil taxonomy unit for the transfer and application of results of agricultural research (see Swindale 1978). Climatic as well as soil physical and chemical characteristics are used to classify soils. The BSP has defined primary and secondary benchmarks as follows.

a. Primary benchmark sites are used for the detailed research needed to establish concepts. They are located on the most important soil families, with perhaps only one site per family.

b. Secondary benchmark sites are used for testing the transferability of the results obtained at primary sites. Fewer research inputs are made than on primary sites, and the sites are intended to be used for perhaps 2 to 3 years. It seemed obvious to our committee that these sites should be located at research stations of the national programs (in India).

The committee recognized the usefulness of the BSP's concepts of two levels of benchmark locations and the defining of an environmental unit (i.e., the soil family in the BSP). However, the identity of this environmental unit was the subject of much discussion. This unit should not be selected only on the basis of soil taxonomy but should perhaps include other criteria, e.g., agroclimate. It was considered desirable that a much larger soil taxonomic unit than the soil family be used.

The soil component of an environmental unit must be much larger than the soil family, solely on the basis of practicability. The soil family is too small a unit for use in the field; even detailed soil maps produced by soil surveyors will usually use a mapping unit of an association which consists of a group of several families with similar characteristics. Larger units should be satisfactory for farming systems research—for example, the present transfer of technology testing involves the "deep Vertisols in assured rainfall areas."

SELECTION OF BENCHMARKS

Selection Criteria

The first stage in this selection of SAT benchmark sites is the consideration of the global geographical SAT requirements. The needs of each region for research to improve production need to be assessed by a number of criteria, e.g., population size and density, economic needs, production levels of major crops, trends in production and population, etc. On the basis of these criteria, the priority of each region for a benchmark site will be decided.

The location of the benchmark site within a region will depend on the major crops, soils, agroclimate, and biological factors (e.g., pests, diseases, etc.). A benchmark site may have more than one benchmark soil; for example, ICRISAT Center at Patancheru is a benchmark center with at least two benchmark soils—Vertisols and Alfisols. To classify, we can list the existing benchmark sites and their major soils as follows:

Benchmark site	Benchmark soil
ICRISAT, Patancheru	Vertisols Alfisols
Sadoré	Psamments
Kamboinsé	Alfisols (toposequence)

Other sites that would perhaps be considered in the future are those to serve the SAT in southern Africa (Entisols, with a higher temperature) and in northeastern Brazil (Oxisols, with a particularly long but erratic rainfall season).

Within a region, there may be need for additional soils outside of the benchmark site to cover known variations in particular environmental aspects, e.g., agroclimate, soils, disease incidence, etc.

Implications

To determine the best location for benchmark sites, there is a need for good resource inventories. These in turn require good soil and agroclimatic surveys. Some compilation and interpretation will be needed for West Africa, because soils were mapped there in a system different from the US Soil Taxonomy. But, for India, the completion of mapping of the country in much more detail than previously, and using the US Soil Taxonomy, will result in a very marked improvement in the soils resource inventory. One aspect of direct relevance to ICRISAT's FSRP work is that we will be able to select benchmark sites for FS1 and FS2 much more critically than on the very broad basis used in the past (i.e., rainfall and soil order, with an additional qualifier of soil depth). The more important sites, out of the 23 originally used, are listed in Table 2. (For descriptions of FS1 and FS2, see Table 4, page 42.)

Table 2. Important benchmarks in India for FS1 and FS2.

Soil order	Benchmark site	Mean length of growing period (weeks)
Vertisols[a]	Indore	16.4 ± 3.1
	Akola	14.0 ± 3.7
	Patancheru (ICRISAT)	12.9 ± 5.8
	Sholapur	11.3 ± 6.4
Alfisols	Ranchi (?)	16.4 ± 3.8
	Ramanathapuram	13.4 ± 5.2
	Patancheru (ICRISAT)	12.9 ± 5.8
	Anantapur	
Entisols	Agra	13.3 ± 3.6
	Hissar	

a. Vertisols are deep at all sites, except at Akola (medium).

Investigations are also needed to determine the size of the environmental units used for selecting benchmarks. Of particular importance is the fact that there has been very little critical work done on the transferability of research results. The BSP studies have provided useful leads. However, it must be kept in mind that the BSP was mainly testing the transferability of the results of component research (e.g., responses to nutrients), whereas we are interested in the development and transferability of farming systems.

RESEARCH AT CENTERS AND BENCHMARKS

The aim of research centers is primarily to develop concepts and technologies. Because of permanent facilities, and the concentration of workers from several disciplines, research centers are best placed for conducting detailed and interdisciplinary research. The establishments at Sadoré and Kamboinsé are considered to be benchmark (regional research) centers, serving as a focus for research for the sub-Sahelian and Sudanian zones. A research center must contain at least one primary benchmark site and possibly several. For example, we must regard ICRISAT Center as having at least two benchmark soil sites—Alfisols and deep Vertisols. The Vertic Inceptisols, or shallow Vertisols, provide a third benchmark.

For the FSRP, it is appropriate to elaborate on the characteristics stated earlier of the different categories of benchmarks.

Primary benchmarks

Detailed basic studies to establish concepts.

Applied and multidisciplinary studies to test applicability of disciplinary concepts under field experimental conditions.

Operational research to provide provisional testing of concepts and new technologies in farming "systems" or "practices."

Secondary benchmarks

Evaluation of transferability of technologies.

Evaluation of validity of concepts (both farming systems and component research).

Involvement of national programs (partial test of transferability).

Primary benchmarks located away from the center will still be occupied with multidisciplinary and detailed research, with the marked constraint that inputs may be limited by the logistical problems created by distance from base.

The distribution of research effort between the centers and the two levels of benchmarks will vary with the attributes of a particular improved technology. However, some speculation can be made (Table 3) to indicate a possible distribution of efforts within each of the five categories of research outlined by Working Group 2.

Table 3. Relative emphasis of farming systems research areas at centers and benchmark locations.

Kind of research	Center	Benchmark	
		Primary	Secondary
Base-data analysis	XXXX	XX	X
Single-component research	XXX	XX	X
Multicomponent research	XXX	XXX	X
Integrated operational research	XXX	XXX	XX
On-farm research			XX

ORGANIZATION OF RESEARCH AT CENTERS AND BENCHMARKS

The organization required for research at benchmark sites will necessarily be specific to location and purpose, but in all cases there will be different requirements at primary benchmarks operated wholly by ICRISAT as compared with the secondary benchmarks operated offsite with other collaborating institutions. Within ICRISAT, there will be a major emphasis on coordination of team efforts, both for concept development and logistics; with offsite work, there will be need to assess the constraints placed by travel, and the constraints and advantages of working with collaborating institutions.

These comments are made especially in the context of ICRISAT in India and West Africa. With current staffing allocations, buildup of centers staffed by ICRISAT in eastern and southern Africa, and South America, is precluded. For these, different staffing and organizational arrangements will be necessary; nevertheless, many of the principles involved in the use of centers and benchmarks will still apply.

One aspect that requires discussion is the extent and nature of interaction between centers in India and Africa. Programs at each center will obviously differ from the others because of differences in the major problems to be researched in each agricultural environment, but there is need for interaction for sharing of resources, ideas, and research methodologies.

CONCLUSIONS

Relatively little critical attention has been given in the FSRP to the criteria to be employed for defining benchmark locations. This has been partly due to lack of resource classifications and inventories in the past, but the basic information required for these is becoming increasingly available. The current developments, within the FSRP, in agroclimatic classification are an example of additional resource descriptions that will improve our ability to select the best.

SUMMARY OF DISCUSSION--SESSION 3

Use and Concept of Benchmarks

Those involved in farming systems research at ICRISAT need to develop technology and to test, evaluate, and distribute it on the basis of a number of sites relevant to ICRISAT. Moreover, farming systems research involves the development of a methodology for selecting benchmark sites.

The concept of benchmarks is extremely useful and should be developed at ICRISAT. Benchmarks help us in stratifying the environment; the more finely stratified, the more they will apply, and the farther we move from the fineness, the less they will apply. Further, we must know the confidence limits for generalization at various levels. These concepts are well understood and can be handled provided that (1) we have well-defined benchmarks that have sensible relationships to each other and encompass the populations, soils, and climates with which we must work; (2) we attempt to spread the information from those locations in a regular, methodological way.

The overall concept is one of understanding and defining the environment for crops, so that we can predict more acurately the areas over which new research findings will be applicable.

Criteria for Benchmark Selection

Similar soils and climate. We should consider not soil alone, but an ecological unit of soil plus agroclimate.

Toposequence. There should be an effort to combine the concept of toposequence with benchmark location. In Australia the concept of landscape units has been developed and used fruitfully by the CSIRO. In West Africa, we have started a systematic use of toposequence for agronomic studies on the adaptation of new varieties and some management techniques, e.g. planting date, soil tillage, etc. We have three sequences in Mali and two in Upper Volta. At ICRISAT there is a special type of toposequence consisting of Alfisols, Vertic Inceptisols, and Vertisols occurring over a short distance. If we consider the Sahelian zone, toposequences are of little value, since we can identify only one, or perhaps two, soil families there. However, in the Precambrian shield areas in Upper Volta and Mali, toposequences are very important.

The toposequence can be considered as a tool to observe the relation of crops to a number of factors, especially if observations are well made and supported by complementary measurements.

Biological parameters. Since we are dealing with biological systems, some aspects that must be taken into account in crop production—in addition to climate and soils—are latitude, altitude, and various insect-cum-disease parameters. These biological parameters, unfortunately, are not stable— they vary considerably from year to year, and a site that is a good benchmark one year may be an appalling one in another year.

Sociological aspects. The benchmark idea is a good one. However, in practice we have human beings in the system and, given a certain socioeconomic setup, we may have to allow time to elapse before adapting technology to suit the socioeconomic conditions.

Regions selected by ICRISAT crop improvement programs. We should take note of the regions identified by our crop improvement programs. Benchmark sites must fit into those regions so that there is congruence between the two sets of objectives. From the cropping point of view, the benchmark regions have already been identified.

Number of Benchmark Sites

T.S. Gill of USAID has calculated that there are about 240 agroecological units for all climatic zones in the world and has posed the question: can we reduce the number of important units to, say, 15?

For the grouping of smaller units into larger units, we have to consider the number of units and variations within them. There is a compromise between the size of the unit and the degree of accuracy. The penalty for failing to characterize the agricultural environment correctly may be the failure of the technology.

We must be careful to identify those particular units that have some significance for our work at ICRISAT.

Existing and Future Benchmarks

We all agree that we must spend most of our efforts on well-chosen and well-characterized major sites that are to be under our own control. This has already been done. We will not have research centers at more than three locations in the world for a long time to come. These locations—two at Patancheru, one at Sadoré—are, in fact, primary benchmarks, well chosen with some scientific logic in mind, and represent a conceptual framework within which we can interpolate and not extrapolate from our current results.

We ought to have at least one more location in Brazil, the fourth and very necessary corner point in our particular sphere of soils and environment, and we hope to arrange this. We are not only choosing our sites very carefully but we are also considering methodologies to extend from them to more finely defined sites around the world.

Possible Assistance in Benchmark Selection

We must look to other people to work on benchmarks when this becomes necessary. Such external work might include the services of an experienced person to identify 15 sites that are of concern to ICRISAT.

Relative Emphasis at the Primary Benchmark Locations

The two ICRISAT centers at Patanheru and Sadoré have provided sites for attacking major agricultural problems within farming systems research in each region. Each center serves a region with its own individual problems; since we have many more scientists at Patancheru, we will be able to study many aspects in greater depth than can be done at Sadoré. Soils at the two sites differ appreciably. At Patancheru we do not have deep sandy soils containing highly weathered clay. The Sadoré site consists of only sandy soils, with no Vertisols. But there is a need to intercommunicate in respect of field and laboratory techniques and methodologies. The effective working relationship between the Indian and the West African centers has received only limited attention so far.

COLLABORATIVE RESEARCH WITH NATIONAL RESEARCH CENTERS

REPORT OF WORKING GROUP 4

S.M. Miranda (Chairman)
Sardar Singh
M.S. Reddy
M.C. Klaij
J. Hari Krishna (Secretary)

INTRODUCTION

Preliminary results from research by national programs in the SAT and by ICRISAT indicate that improved resource conservation and utilization, along with improved technology applied to all phases of crop production, have great potential for generating economically and technologically viable farming systems capable of increased and more stable agricultural production. However, the resource base (climate, soil, people, crops and cropping systems, livestock, capital, etc.) is characterized by great diversity. Even at a given location, the environment for crop growth will differ from year to year due to the variability in rainfall. Therefore, appropriate farming systems technology will have to be flexible to perform well under a range of conditions.

The diversity of the resource base encountered in the SAT dictates the need for associated research at benchmark locations. These locations should be carefully chosen in cooperation with national programs to represent distinctly different climate, soil, and topographic conditions, and to cover the spectrum of environment with a minimum of locations.

Farming systems research results are likely to be substantially site-specific, and principles that may be developed at ICRISAT Center must be further tested and modified in local environments. Distinct guidelines and established methodology are not readily available in farming systems research as they are, for instance, in plant breeding research. It is important, therefore, that farming systems research be strengthened and adapted through international, national, and regional cooperative programs.

REVIEW OF PAST REPORTS

In 1973, when FSRP/ICRISAT was in its infancy, the program committee of the Governing Board recommended establishing a network for research on associated production factors as well as watershed-based research programs at benchmark locations.

Subsequently, in 1975, Norman and Wright discussed a number of ways in which farming systems scientists could conduct research outside ICRISAT Center. The simplest and most straightforward suggestion was for ICRISAT to purchase land in suitable locations in India and to operate these as ICRISAT subcenters, as CIMMYT had chosen to do in some locations in Mexico. Another approach, more difficult to manage, but undoubtedly more appealing, was to

establish working arrangements with the appropriate Indian institutions for cooperative research at specific locations. It was suggested that ICRISAT enter into agreements with individual coordinated projects or universities for the specific type of cooperative research deemed necessary and mutually desirable.

Norman and Wright also indicated a clear need for the FSRP to establish benchmark locations within India, where research findings from ICRISAT Center could be tested and, if necessary, modified. These locations were thought of as representing agroclimatic zones substantially different from that of ICRISAT Center.

The view of the farming systems scientists then was that the work should be concentrated and the number of sites limited, so as to permit a strong coordinated effort at such centers. Three locations were proposed: a black soil region of about 500 mm/yr rainfall, a black soil region of about 1000 mm/yr rainfall and a red soil region of about 500 mm/yr rainfall. The working hypothesis was that these would represent the extremes of the hydrologic environment with which ICRISAT was likely to be concerned in the near future, with ICRISAT Center representing the intermediate environment. ICRISAT staff—an agronomist, a soil and water engineer, and an agricultural economist—were recommended for each research center.

The Stripe Review (held in 1977) recommended that cooperation with national programs should always be pursued on partnership terms rather than via a hierarchically directed approach. The TAC/CGIAR Quinquennial Review Mission (1978) felt that ICRISAT's research results cannot benefit the farmer until its improved technology is adapted and proven at the national level. To emphasize this need and accelerate the process, ICRISAT set up a Technology Transfer Committee (TTC) to deal with training, seminars, and workshops, the transfer of technology, and relationships with other institutes. There is a need, however, for greater participation of the TTC in establishing collaborative research programs in farming systems now.

Gilbert et al. (1980) state "Farming systems research has been applied in relatively few areas of the third world—with limited results. Clearly, major inputs of resources in FSR programs will be required for any hope of significant impact on large numbers of small farmers. Given the holistic nature of FSR and the fact that much of the work is location-specific, to provide even cursory coverage of major regions of the developing world will require significant resources. Such resources are unlikely to be available from existing national agricultural research programs, which tend to be poorly staffed and underfinanced." International centers, on the other hand, are best suited to conduct farming systems research at primary locations and, through cooperative arrangements with national and regional institutions, to refine the technology further for adoption at the farm level.

BENCHMARK LOCATIONS

It must be recognized that the choice of benchmark locations for collaborative

research depends upon the regions identified for such studies. Since Working Group 3 is responsible for identifying benchmark locations, we feel that the details of cooperative work in various regions should await the recommendations of the Group. Yet an attempt is made here to suggest possible areas for collaborative research. The deep Vertisol technology developed at ICRISAT is used as an example, and studies to refine it in cooperation with national and regional institutions are indicated.

COLLABORATIVE RESEARCH IN INDIA

Approaches and Possible Areas

It is expected that when benchmark locations are identified, various levels of priority would be established for these areas. A very limited number of primary benchmarks could be set up, followed by a large number of secondary benchmarks where collaborative research is envisioned. It is important that scientists and administrators from national programs be involved in identifying areas for collaborative work as well as for establishing the methodology for field research.

Once the benchmark locations and priorities are established, this group recommends that joint meetings be convened between farming systems scientists and scientists from national and regional institutions to decide the specific areas where ICRISAT can successfully contribute through collaborative research. Examples of such work include FS1 and FS2 experiments, as well as cooperative work in sorghum growth modeling.

The responsibilities of ICRISAT scientists and other cooperators, as well as the objectives of the proposed collaborative experimentation, should be clearly spelled out. It is felt that universities should receive special attention with regard to our collaborative activities in the future.

In the context of improved farming systems, some topics for possible collaborative research are suggested.

- Collection and analysis of base data.
- Maintenance of fertility status in SAT soils through low-cost inputs.
- Soil and water management for in situ conservation.
- Runoff collection, storage, and cycling of water.
- Cropping systems and agronomic research.
- Testing of improved implements.
- Evaluation of improved crop production technologies under different environments.

The research can be exploratory and development-oriented for solving specific problems identified. It can also be integrative where components are assembled and tested in a holistic framework.

Technology for Double Cropping on Deep Vertisols

The watershed-based broadbed-and-furrow system of land management coupled with improved systems of cropping have consistently resulted in the possibility of double cropping on deep Vertisols at ICRISAT. High crop yields have been realized both in the rainy season and in the postmonsoon season. Such technology has great potential for application to large areas of deep Vertisols in India, particularly those under assured rainfall conditions. Before any technology can be recommended to the farmer in the real world, however, it is necessary to test and fine-tune it in collaboration with national and regional scientists at benchmark locations.

As an example, the deep Vertisol assured-rainfall area comprising parts of Madhya Pradesh, eastern Maharashtra, and northern Andhra Pradesh could be considered here as one such region. Two or three benchmark locations could be chosen within this region; the places suggested are Indore and Bhopal in Madhya Pradesh. ICRISAT Center would continue to serve as a primary benchmark. The collaborative work envisaged is basically that of testing the land-management technology and improved farm equipment and cropping systems in several ways. Table 4 indicates the suggested collaborative setup.

Table 4. Suggested collaborative research setup on deep Vertisols under assured rainfall conditions in India.

Location	Collaborating agency	Suggested experiment
Indore, Madhya Pradesh	AICRPDA (ICAR)	Evaluation of broadbed-and-furrow system against other land-management treatments (FS1)
	Indo-UK Project	Evaluation of watershed-based improved resource- and crop-management technology (FS2)
Bhopal, Madhya Pradesh	Central Institute of Agricultural Engineering (CIAE)	Evaluation of broadbed-and-furrow land-management systems (FS1)
ICRISAT Center, Andhra Pradesh	AICRPDA (ICAR)	FS1 and FS2[a]

a. FS1 and FS2 are collaborative studies between ICRISAT, AICRPDA, and the Central Water Conservation Research and Training Institute. FS1 is concerned with studies on resource development, conservation and utilization with reference to soil and water, and FS2 with hydrological studies to improve land and water utilization in small agricultural watersheds of SAT India.

It can be seen from Table 4 that several modifications to the present collaborative work are being suggested. They are as follows.

1. Limited number of locations. Instead of working at many different Vertisol locations distributed over India, as at present, only two places are being suggested. They are positioned north of ICRISAT.

2. Variety of collaborative agencies. Rather than working with AICRPDA alone, links with other national and central projects as well as with regional institutions are considered advisable. This will allow us wider exposure, and the benefit of evaluation by a greater number of professional colleagues.

3. FS1 and FS2 at one location. At present, there is no Vertisol experimental site outside ICRISAT where both FS1 and FS2 are located together. Indore is therefore suggested as a place for such comprehensive evaluation, since FS1 and work similar to FS2 are already being done, at the dryland center and through the operational research project.

4. Clear distinction between FS1 and FS2. Some ambiguity still exists in the minds of our collaborators with regard to the above experiments. It has to be clearly established that in FS1 we are looking at the land-management technology per se. In FS2 a comprehensive evaluation of all components of the farming system (and participation of all subprograms) is intended. It may, however, be possible to use FS1-type experiments to study other individual components of farming systems as well.

It is important that the experiments be carefully planned and executed, in consultation with the concerned scientists at the selected locations; the present number of locations where collaborative experiments in FS1 and FS2 are being conducted should be reduced so that, with the manpower and resources available to us, reliable results of good value could be obtained from a few selected benchmark locations in well-identified regions.

COLLABORATIVE RESEARCH IN AFRICA AND OTHER SAT REGIONS

The nature of the collaborative research in Africa and other SAT regions will depend very much on the farming systems research to be given priority at the ICRISAT centers and benchmark locations. It is expected that in these collaborative efforts the input of the ICRISAT scientists will be greater at the other ICRISAT centers than it is in India. This will continue to be so until the national research capabilities in the region are built to a level comparable to the Indian national research system. Collection and analysis of base-line data for various SAT regions are required. It could be envisaged that collaborative research on development of improved farming systems—especially on land and water management for the light-textured Entisols with low water-holding capacity and high susceptibility to leaching—would be needed in Africa. Development of appropriate farm machinery and cropping systems, with millet and sorghum bases, adapted to limited moisture and nutrient stress situations, would be equally important. In Latin America, particularly in Brazil, specific interest has been expressed

in land and water management and in cropping system aspects of farming systems research. Similar examples can be cited for the rest of the important SAT regions.

Other areas of collaboration, with the objective of developing the national research capabilities, are the training of workers in research and the joint organization and holding of conferences, symposia, and information activities to discuss and disseminate research results and strategies. It is felt that strong national research systems will help accelerate the generation of viable technological solutions addressed to specific agricultural production problems confronting various SAT regions.

SUMMARY AND CONCLUSIONS

1. Since farming systems research tends to be highly location-specific, collaborative research at various locations is required for testing and fine-tuning.

2. Past reports have strongly recommended the identification of benchmark locations and the conduct of collaborative research with scientists from national programs.

3. After benchmark locations are identified by Group 3, there is a strong need to convene meetings of ICRISAT scientists with those of other institutions to identify the problem and jointly suggest suitable collaborative research topics and procedures for various regions.

4. It is important that research be conducted in collaboration with several national and regional institutions rather than with any single organization, although the total number of centers where research efforts could be concentrated should be limited. Agricultural universities should receive special attention for collaborative work in the future.

5. In collaborative research, greater participation of ICRISAT scientists is required in those countries where national research programs are not yet fully developed.

SUMMARY OF DISCUSSION--SESSION 4

The classification of primary, secondary, and tertiary benchmark locations was further clarified, especially in relation to collaborative research with national research centers. Because of the limited resources at ICRISAT, the group generally felt that only a few benchmark locations should be identified. It was pointed out that the discussion paper for this session was very much oriented towards India, and a suggestion was made that the problems should be identified first and the benchmark locations chosen after such identification.

Several other important questions were raised. How far should we involve ourselves with the national programs? Should they be involved right from the planning stage or only at later stages? How can we work with more than one national agency in a country? It was suggested that duplication should be avoided in working with national research centers. Interfacing correctly with the national program is important.

Collaborative research with other institutions was discussed. In India, both regional research organizations and agricultural universities could be included in collaborative research. In many African countries, on the other hand, it might be better to work only with the national research systems. In countries where the national research system is not fully developed, greater participation by ICRISAT farming systems may be required. In Latin America, it was suggested, we should develop a cooperative arrangement with the national research center at Planaltina, outside Brasilia, in Brazil. This would be a good benchmark for the highly aggregated clays in wet-dry semi-arid tropics.

It was also pointed out that utilization of the product—harvesting, storage, marketing, etc.—had received little attention and that it should be decided at various levels whether, and to what extent, ICRISAT should be involved in such work.

ON-FARM RESEARCH

REPORT OF WORKING GROUP 5

G.E. Thierstein (Chairman)
P. Pathak
O.P. Singhal
J.G. Ryan
T.S. Walker
S.V.R. Shetty (Secretary)

NEED AND RELEVANCE OF ON-FARM RESEARCH

At the center of farming systems research are the farmers who, together with their families, should be intimately involved in any research aimed at improving their farming systems. On-farm research (OFR) at ICRISAT should be a holistic search for technological solutions to production problems caused by socioeconomic, physical, biological, and institutional constraints. The instruments for OFR are many, and include agronomic field observations, socioeconomic analyses, diagnostic experiments, field trials, adoption studies, and impact assessment. A close working relationship between the researchers and farmers remains the essential ingredient in effective OFR that allows farmers' agroclimatic and socioeconomic environments to influence technology design.

Although ICRISAT is an international agricultural research institute without a primary responsibility for developing location-specific technologies, it cannot divorce itself from OFR. Without OFR, the vision emanating from a farming systems research focus will be seriously impaired. This is because scientists have little assurance that identified research priorities address actual farm problems, that proposed solutions measure up to expectations under farmers' conditions, and that related technologies have potential for rapid adoption by farmers.

OFR at ICRISAT should involve one or more reseach activities conducted in carefully selected benchmark farm situations, in order to describe and diagnose problems facing farmers, evaluate technology options, and monitor the adoption and performance of technologies. OFR has demonstration value in the transfer of technology, but extension is primarily the responsibility of a national program.

OBJECTIVES

1. To study the existing farming systems in an effort to identify farmers' constraints to production, and indicate potential research areas.

2. To test, screen, and evaluate technology options—components and/or systems—under real world situations.

3. To monitor the adoption and assess the impact of technologies.

4. To develop and test OFR methodologies and approaches, and participate in training programs with OFR field activities.

5. To provide a channel for technology transfer in cooperation with national programs.

6. To transfer information between farmers and researchers.

STRATEGY AND ACTIVITIES

OFR must be a legitimate function, both at ICRISAT Center and at benchmark sites. Specific research thrusts of major importance to the SAT should be identified for concentrated OFR efforts. At present ICRISAT's village-level studies are the primary focus for ICRISAT's OFR. In the future, the village-level studies will continue to play an important role in ICRISAT's OFR activities.

One or more activities may be designed to meet each of the above-listed objectives; but it should be recognized that a strong complementarity exists among OFR activities. ICRISAT should exploit the full complementarity between various objectives. Table 5 suggests six major activities for ICRISAT OFR.

1. Base-data collection analysis. Reconnaissance or exploratory enquiries and formal surveys that are necessary to obtain baseline data, to describe existing systems, and to identify important production constraints.

2. Diagnostic or exploratory research. Agronomic and socioeconomic observations and field experiments to understand and quantify the effects of different factors of production on the overall performance of the system; identification and further evaluation of the technological components that are designed to alleviate the production constraints.

3. Technology testing. Field trials to evaluate designed technology options.

4. Adoption and impact assessment. Studies aimed at monitoring adoption of technologies and assessing their impact. These studies also emphasize identification of institutional constraints to adoption.

5. Training. Field activities related to OFR training, which should build a curriculum of practical skills and methodologies for OFR in national programs. Methodologies and concepts for training will evolve as OFR experience accumulates in ICRISAT.

Table 5. Relationship of on-farm research (OFR) objectives and activities.

Objectives	Activities (strategy)					
	Study existing systems and identify problems for on-center research	Evaluate technologies under real-world situations	Monitor adoption and assess impact	Develop OFR methodologies and approaches	Assist technology transfer	Channel information between farmers and researchers
Base-data collection and analysis	XXX	X	X	XX	XX	XXX
Diagnostic or exploratory research	XXX	XX	*	XX	X	XX
Technology testing	X	XXX	X	XX	XX	XX
Adoption and impact assessment	XX	X	XXX	XX	XX	XXX
Training with field activities	XX	XX	XX	XXX	XX	XX
Special projects for technology transfer	X	XX	XX	XX	XXX	XX

XXX = Activity specifically designed for objective

X = Activity may contribute to objective

XX = Activity strongly complementary to objective

* = Little or no complementarity with objective

6. Technology transfer. On-farm operational experiments can be used to transfer identified technology options to national programs, which have primary responsibility for extension. However, wherever necessary, special projects (including demonstrations) can be carried out to promote technology generated and recommended by ICRISAT. These projects represent an important transition in responsibility from research to extension.

The relative emphasis given to any one of these OFR activities will depend upon the regional focus and stage of FSR development at any point in time.

MANAGEMENT AND ORGANIZATIONAL STRUCTURE

OFR should be considered as the first and last link in the ICRISAT farming systems research chain. It should be designed to complement and support on-station research at ICRISAT Center and at benchmark/cooperative research locations. The on-station research should recognize the need for, the relevance, and the importance of OFR.

The same scientists who conduct on-station research must be responsible for the design, execution, and management of OFR. However, there is a definite need to coordinate OFR. A principal scientist should head such a coordinating unit. Proposals for OFR should be reviewed by the OFR coordinator prior to submission to the Director of Research.

A schematic structure of OFR activities in relation to on-center research is shown in Figure 3. The multidisciplinary field-scale production systems research at the center will act as an important bridge between disciplinary research and on-farm field experiments.

OFR IN ICRISAT AND NATIONAL PROGRAMS

ICRISAT OFR should focus on methodologies and approaches applicable to regions and their common problems. Training in OFR concepts and methods is also an important responsibility. National program OFR should be primarily responsible for location-specific technology development.

Some national programs have a broader network of research and development activities than others, and are thus in a good position to conduct downstream FSR activities and also provide excellent feedback for further research. Thus it is essential that there be good lines of communication between national and ICRISAT programs to supplement and complement each other's OFR experiments.

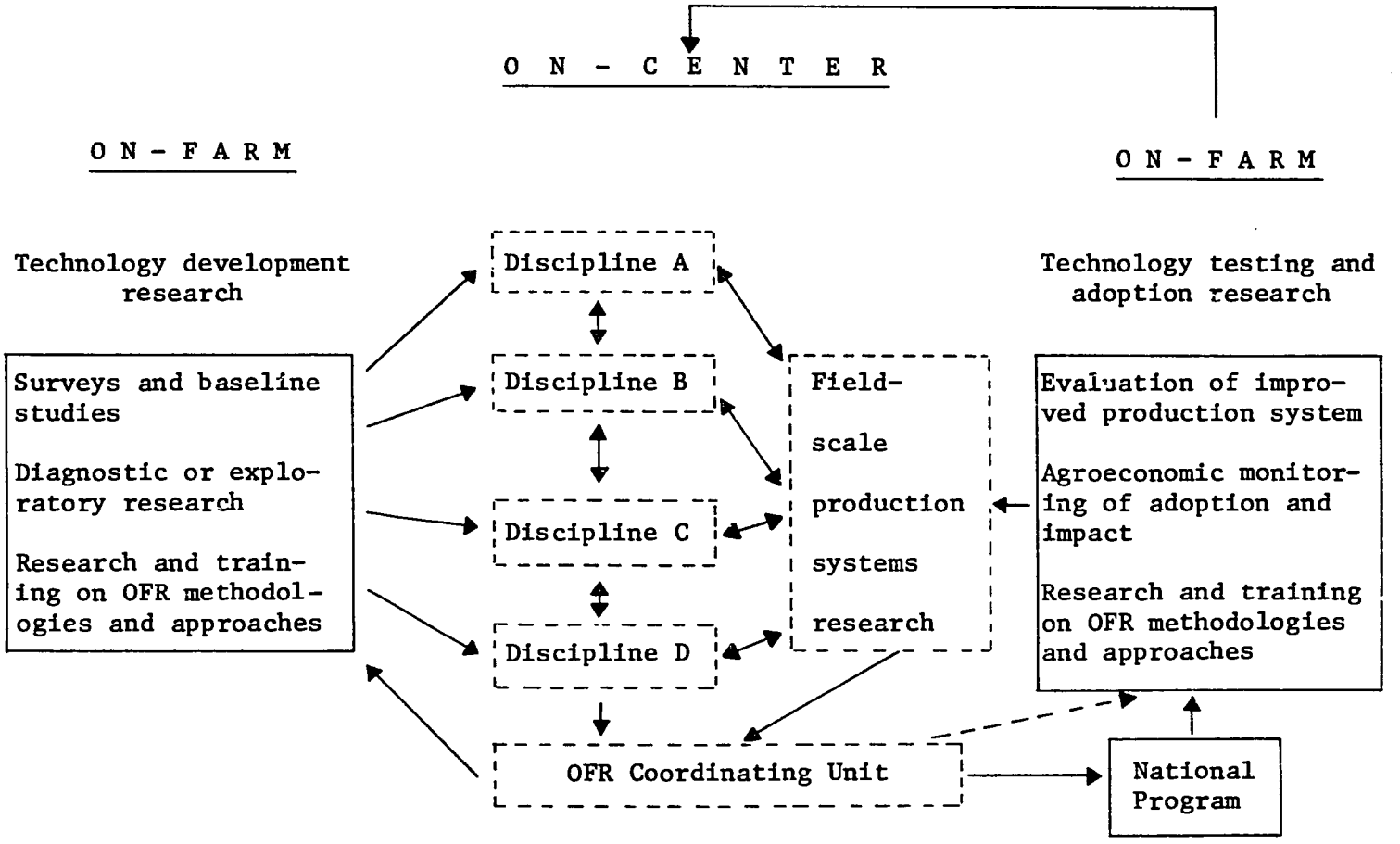

Figure 3. Relationship of on-farm and on-center research.

Whenever and wherever possible ICRISAT should directly participate with national programs in the on-farm testing of technologies (Fig. 3). In countries where downstream activities are not highly developed, ICRISAT must still be involved in on-farm testing of technologies in order to maintain the holistic focus of farming systems research. It is here that joint development with national programs of on-farm testing of methodologies and principles will have a high payoff.

SUMMARY OF DISCUSSION--SESSION 5

Relevance of On-farm Research

There was unanimous agreement regarding the need for and the relevance, objectives, and activities of ICRISAT on-farm research (OFR), as described in the paper. All the participants stressed that OFR should be considered as a legitimate function both at ICRISAT Center and at benchmark sites.

Role of On-center Scientists in OFR

There were diverse opinions on the most appropriate personnel to be assigned to on-farm research. It was generally felt that all scientists should be encouraged to involve themselves in OFR to some degree but that those identified specifically for OFR work should not only be capable of undertaking such work but also be motivated towards it.

A separate coordinating unit headed by a strong and experienced coordinator is essential for managing OFR activities. Diagnostic and investigative research may be conducted under individual disciplines, but systems evaluation should be attempted only through a team approach.

Collaboration with National Programs

All OFR activities should be conducted through and with national program scientists. Some concern was expressed regarding the diagram of OFR activities, in which a loop was provided for bypassing the national programs for on-farm testing of technology. Many participants felt strongly that national programs should not be bypassed at all, and that national program scientists should be involved at all stages of farming systems research, because it is by the actual increase in productivity at farm level that the Institute's contribution will be finally judged.

It was also felt that the researchers should withdraw from a supervisory role after a few years but continue to monitor the adoption and assess the impact of the technology tested. Proper associations with national programs are therefore necessary. ICRISAT should also encourage national programs--which often overlook the need for OFR--to initiate on-farm research.

In some disciplines, such as agricultural engineering, ICRISAT also needs to work with another intermediary, namely, the manufacturers and agencies promoting farm machinery.

Base-data Collection and Analysis

It was generally agreed that OFR is important in gathering socioeconomic and some agronomic base data. Any data related to agroclimate should be analyzed at the center, and some basic on-center studies are also needed to gather some types of agronomic data. Ex ante studies are needed to assess alternative research possibilities.

Technology Transfer

ICRISAT should not be involved in the transfer of technology as such, but should conduct research only on the transferability of the technology developed, and screen the technology to be transferred to farmers.

Not all farming systems research technology needs to pass through on-center production systems research before being tested on-farm. In certain cases OFR could precede on-center research.

Monitoring of Technology Adoption

Monitoring is necessary to modify research strategies, depending upon feedback information, and to assess the payoffs from any new technology. Indirectly these studies would also help to quantify ICRISAT's contribution to the process of change.

INTEGRATION OF SCIENTIFIC RESEARCH ACTIVITY

REPORT OF WORKING GROUP 6

J.T. Moraghan (Chairman)
C.N. Floyd
V.V.N. Murthy
M.V.K. Sivakumar (Secretary)

INTRODUCTION

Farming systems research is multidisciplinary in nature and aims at reducing the gap between actual and potential farm yields. It involves the determination of the constraints that are causing the production gap, and of ways to overcome them scientifically, socially, and economically.

Farming systems research provides a means by which multidisciplinary teams of researchers can examine problems of the farming system, including complementary and supplementary relationships between resources. It essentially involves a holistic approach to the problems of agricultural production (Gilbert et al. 1980). In the opinion of the Technical Advisory Committee of the CGIAR, reviewing farming systems research in 1978, the characteristics of the research transcend those of conventional disciplinary research in that the research, through multidisciplinary effort, seeks to improve the efficiency of the agricultural research process by focusing on farmers' problems and their needs to develop improved technology.

A schematic representation of the FSRP at ICRISAT is illustrated in Figure 4 (Kampen 1980). The program leader's role is not listed in this figure, but presumably such a person is associated with all aspects of the program. The Coordinating Unit was not defined.

OBJECTIVES

The group considered integration of scientific research activity with the following objectives.

1. To discuss the need for and relevance of multidisciplinary research projects.

2. To study problems associated with integration of farming systems research at ICRISAT Center.

3. To study problems associated with integration of farming systems research at ICRISAT Center with that at benchmark sites.

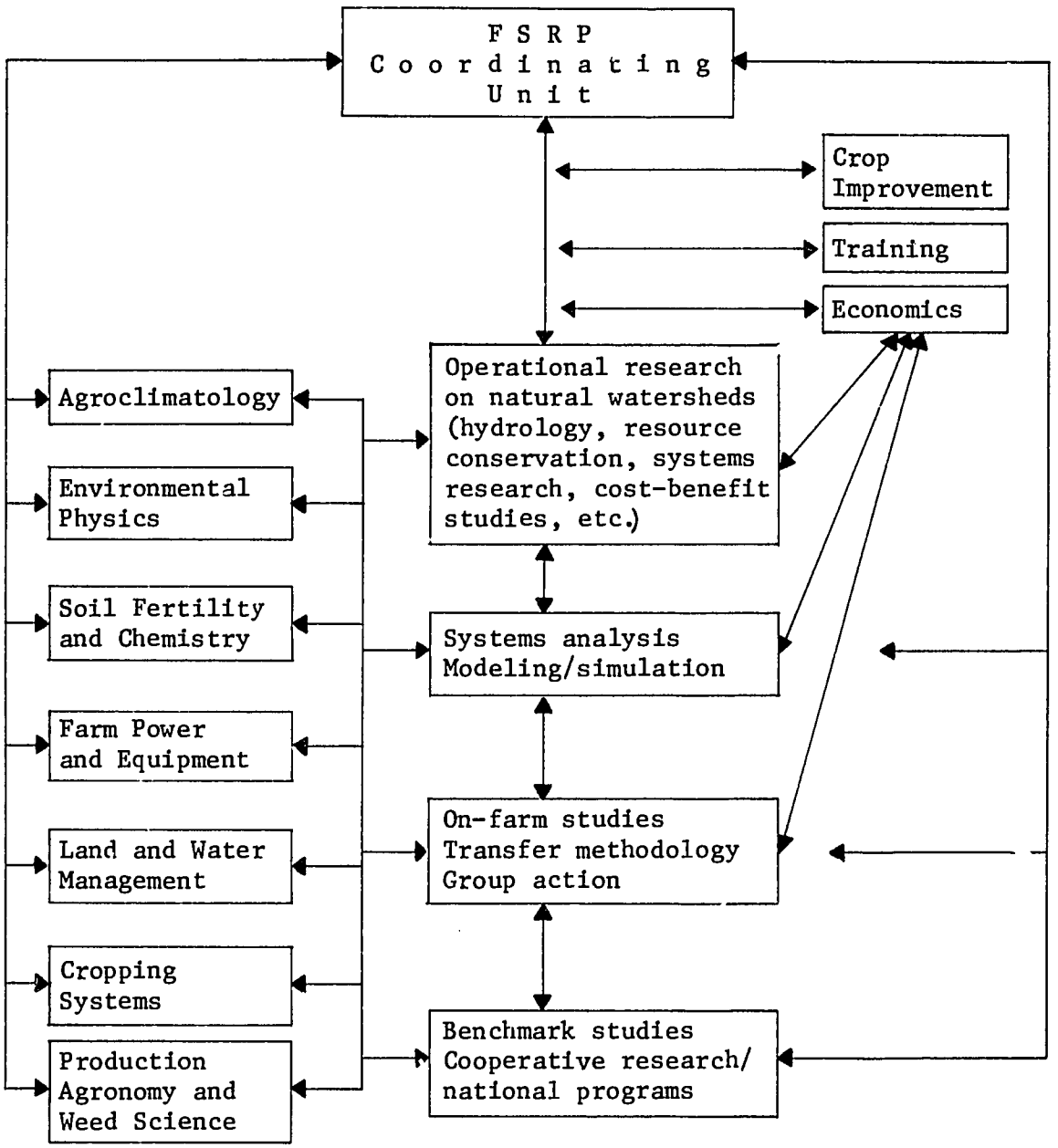

Figure 4. Proposed organizational chart of ICRISAT's Farming Systems Research Program.

4. To recommend procedures for encouraging team research.

MULTIDISCIPLINARY RESEARCH--NEED AND RELEVANCE

Much agricultural research in developing countries in the past has been based on narrow disciplinary approaches, and, for the farmer, integration and application of new information has been difficult. Determination of constraints, problem identification, and subsequent analysis should be approached in a multidisciplinary fashion. The structure of discipline-based research, and constraints on facilities in the national programs, have not always been conducive to effective multidisciplinary studies. The structure of the research programs at the international agricultural research centers provides both the environment and the opportunities for team research that allow a more complete analysis of the components of the factor(s) under study. A distinguishing feature of farming systems research is its recognition of the interdependence of factors that affect the on-farm production process; multidisciplinary research in such a group should be emphasized.

Judging from the organizational chart of the FSRP (Fig.4), the relation of different subprograms to centralized activities (such as operational research on natural watersheds, systems analysis and modeling/simulation, on-farm studies, and benchmark studies) would be multidisciplinary in nature. It appears to be essential to evolve a system of satisfactory working arrangements between different subprograms that contribute to the planning and execution of these different activities.

As M.B. Russell has concluded (personal communication): "More attention should be given to answering the question - Why? - instead of just recording - What? This is the challenge of working on such complex systems of dynamic and site- and season-specific problems."

However, some caution is appropriate. Multidisciplinary research could be "weak in theory and soft in quality" (Schultz 1979). It may be easy to "jump on the bandwagon", but it is important for the disciplines concerned to steer the wagon in the right direction.

The newly evolving field of dynamic systems models has great potential for handling the complex interactions of processes that characterize on-farm production. Data collected from the multidisciplinary investigations could be effectively used in the development of "weather-driven" crop-production models, which would provide a vehicle for the continued involvement of the group in a holistic treatment of our work. Interactions and interdependencies of various processes could be identified. Also, the inherent responsiveness of crops to various production factors could be established to indicate the potential for improving and stabilizing production by suitable technologies that manipulate these factors.

A strength of multidisciplinary team effort is that it may make more efficient use of resources than alternative approaches. The scientists involved in single-factor oriented farming systems research may often find

that, by suitable planning and communication, duplication of research efforts can be avoided. Nevertheless, planners of multidisciplinary experiments should recognize that varied requirements of different scientists need to be blended into a single experiment. For example, a study of the response of crop to canopy-architecture modifications involves considerations of agronomy, soil physics, soil fertility, agroclimatology, and so on. Reduction in duplicated efforts would free more resources for other appropriate activities.

Multidisciplinary research conducted over a series of years could yield valuable data on the response to different factors as well as to season-specific parameters. It should be possible to devise an effective means of cataloguing the data from this research. Such congruent data sets would be valuable in validating or evaluating a model or a methodology developed elsewhere for SAT situations, and for identifying research priorities.

The FSRP's approach should be a "systems approach" (TAC 1978); this is inherent in the committee's treatment of the subject. Integration is fundamental to this approach and is required at all levels and in all activities. The problems associated with integration are seen in a hierarchial arrangement with many of the minor problems being derived from basic (major) problems. Basic problems are classified as those associated with: (1) the systems approach; (2) the conceptual framework and structure of farming systems research; (3) reporting and evaluating such research; (4) leadership.

Despite this classification, an important characteristics is the association between the basic problems.

The Systems Approach

The systems approach to agricultural research is a relatively new and little-developed concept. The following are problems associated with its adoption.

Commitment to the approach. To be effective and operate successfully, the systems approach requires participants to adopt a more altruistic attitude to their work than is conventionally required. Unless participants are committed to the approach, there may be problems in generating the attitudes required for its successful operation.

Training. Scientists may often be inadequately prepared to operate effectively in integrated research, either because they did not receive a formal systems training or because the training was theoretical and/or inadequate for practical use.

Methodology. There is a lack of easily identifiable and applicable methodologies in the systems approach, particularly for farming systems research; experience may play a key role in their development. The committee notes that TAC (1978) regards the development of such methodologies as an

important aspect of farming systems research at the international agricultural research centers.

Evaluation and reward of scientific ability. Conventional evaluation and reward systems, which do not adequately recognize an individual's scientific ability in terms of his contribution to group (rather than individual) achievement are not conducive to integrated research.

The Conceptual Framework and Organizational Structure of Farming Systems

The major problems associated with this research (Fig.4) are the following.

1. Absence of a satisfactory mechanism for establishing goals, priorities, and allocation of resources.

2. Incomplete definition and coordination of research activities, particularly those of an integrated nature, designed to meet farming systems research goals.

3. Insufficient flexibility to respond to changing circumstances and new ideas.

4. Inadequate encouragement of activities and communication among subprograms and between the FSRP and other ICRISAT programs.

These problems arise because farming systems research lacks an effective conceptual framework and organization, and because insufficient time and expertise have been devoted to their definition. The concept of a coordinating unit (Fig.4) is little utilized within the present structure of the FSRP.

Reporting and Evaluation of Research

Problems in this area are seen as universal, but in the FSRP are associated and aggravated by problems of organizational structure. Reporting and presentation of research data tend to follow the FSRP's fragmented structure and provide little scope for evaluating the integrated results of the Program.

For the FSRP, the major problems are: an insufficient range of forums for presentation, discussion, and evaluation of research, and insufficient recognition of the importance of such activities. In this respect, there is no clear understanding of the nature and function of the Coordinating Unit. Particular problems within the FSRP are that meetings at program level cover many topics in a relatively short time (in-house reviews) or are concerned with administration (monthly meetings), or, in the case of seminars, are rarely geared towards integrated research.

Leadership

Effective leadership at all levels of the research structure is a central problem in integrated research activities. The problem becomes more critical at upper levels.

Two particular problems are identified. First, coordinating the execution and reporting of multidisciplinary projects. Secondly, specifically in the FSRP, the allocation of sufficient time by the program leader to appropriate "program leader" activities, as distinct from administrative duties and/or subprogram commitments.

PROBLEMS OF INTEGRATING RESEARCH BETWEEN PATANCHERU CENTER AND OTHER BENCHMARK SITES

The chief problem associated with the coordination of center and other benchmark research activities is one of communication. This is accentuated by geographical separation, especially in the case of farming systems research in Africa. The relationship between the FSRP at ICRISAT Center and staff at the African benchmark locations is not clear. Researchers located at ICRISAT may not comprehend the difficulties that affect the scientists at benchmark locations. These locations often do not provide as satisfactory a research environment as that at ICRISAT, and scientists located away from ICRISAT Center are more likely to develop feelings of frustration.

PROCEDURES FOR ENCOURAGING TEAM RESEARCH

Efficacious team research is often enhanced by the following considerations

1. Establishment of research priorities. The committee is of the opinion that additional forums are needed for the interchange of ideas for establishing research priorities and discussion of multidisciplinary projects. Determination of priorities is a difficult procedure, and the scientific staff must be well informed to be able to participate effectively in the decision-making process. If resource allocation should become necessary, extensive background briefings will be needed. The definition, functional nature, and composition of the FSRP Coordinating Unit need to be clearly outlined. Steps should be taken to ensure effective equilibrium between the Coordinating Unit and the subprograms. The Unit should evaluate the present status of the multidisciplinary effort involved in farming systems research, and formulate goals and priorities for the immediate future. Additional means to assist this Unit are required.

2. Careful selection of team leaders. The success of the FSRP must to a large extent be dependent on the careful selection of the program leader. Apart from appropriate professional standing and administrative abilities, characteristics desirable in a program leader include the ability to: communicate, be tactful and considerate in dealing with others, recognize and resolve conflicts, make decisions, and, in general, provide firm leadership.

Procrastination is seldom a desirable characterstic for effective leadership. The program leader should not have additional responsibility for a subprogram. A short-term rotational type of leadership is not recommended for the FSRP, and the consensus of the scientific staff concerned is that a relatively permanent appointment is required. Similar considerations apply to the selection of leaders of multidisciplinary research projects.

3. Recognition of the efforts of individual members of multidisciplinary research teams. All members of multidisciplinary research teams must be especially cognizant of the need to record recognition of those who contribute to the scientific success of such teams. Problems sometimes arise when some researchers are not given authorship recognition on publications arising from joint research. It appears to be important for administrators to recognize effectively the contribution of staff members' participation in team research. The frequency of principal authorship may be decreased for some members participating in research teams. Clear guidance from administrators that effective participation in multidisciplinary projects is recognized is very important.

4. Effective planning of team research efforts. Careful and detailed planning of multidisciplinary research projects is imperative. The responsibilities of each member, particularly of individuals working on different aspects of the same experiment, must be clearly defined. The project leader, at opportune times, should call meetings to expedite the free flow of information and the interchange of ideas.

5. Evaluation of multidisciplinary projects by outside consultants or examiners. Periodic examination of the progress of multidisciplinary research projects by competent experts from outside the institution should increase the efficacy of multidisciplinary research projects.

6. Avoidance of conflict of responsibilities. Any conflict for researchers between subprogram reponsibilities and those associated with multidisciplinary projects may affect overall efficacy. Administrators must not allow the subprogram concept within the organizational framework for farming systems research to affect multidisciplinary research detrimentally.

7. Encouragement of research at benchmark sites. Administrators must encourage communication among scientists at the ICRISAT research locations. Budgets should be adequate to allow appropriate exchange visits. Careful attention must be paid to the type of scientists located at benchmark sites. Such individuals must be extremely capable and should not easily allow frustration to detract from their effectiveness.

8. Clarification of relations between ICRISAT research locations. Clarification is needed of the administrative relationships between the FSRP at ICRISAT Center, Patancheru, and at the African benchmark locations.

9. Periodic review of the conceptual framework of farming systems research. Institute-level meetings should be convened to discuss the conceptual framework of farming systems research in relation to new and emerging needs

for research, and to evaluate the scope for accommodation of new ideas within the framework under operation. The guidance and participation of experts in such discussions is recommended.

10. Coordination of future multidisciplinary work. The Coordinating Unit should be activated and, in a multidisciplinary manner, should implement projects in the major areas of thrust outlined in the 10-year plan (ICRISAT 1982).

SUMMARY OF DISCUSSION--SESSION 6

Concept of Multidisciplinary Research

The situation at ICRISAT is fundamentally different from that, for example, at the International Rice Research Institute (IRRI), where only a cropping systems (not a farming systems) program is in operation. The questions to be considered here are the concept of a multidisciplinary approach, the priorities to be established, and the place of leadership in the whole system.

We should aim at delivering a package of technology to the farmer. The suggestion made by a consultant regarding the abolition of the subprograms and the formation of multidisciplinary groups was considered; but participants felt that the budgetary provisions should continue as they are.

Organizational Setup

Farming systems research is esssentially a research strategy. The organizational setup needs to be considered, but it is important to create a proper environment for multidisciplinary work. More attention should be paid to the why than to the what, and we should also consider the how, an important question in the philosophy of farming systems research. The FSRP needs strong leadership and effective organization. Although the organizational chart (Fig.4) shows a Coordinating Unit, this has not yet become functional. But such a unit is necessary to multidisciplinary research.

Role of Modeling in Farming Systems Research

Systems analysis and modeling provide the framework for multidisciplinary teamwork and the integration of various components of technology. Even whole-farm modeling is important. Sorghum modeling in the FSRP, incorporating research in agroclimatology, environmental physics, plant physiology, and crop improvement was cited as a successful effort to integrate work from several disciplines.

Other subjects that could be examined through modeling are: the profitability of supplemental irrigation during the rainy season; nitrogen in soils; and disease and pest situations. Comprehensive models are difficult

to develop, and setting priorities for modeling is essential. It is also important that the baseline data be compatible for models, and that each experiment be conducted and data collected in such a way as to be compatible with modeling needs.

Modeling, however, is not an end but one effective means of contributing to the mainstream of research activity, and this point should be kept constantly in view. The ultimate objective is to arrive at some decisions for field application, and the development of simulation models for runoff and their use for water harvesting and supplemental irrgation in black soils was cited as an example of effective modeling.

SUMMARY OF GENERAL DISCUSSION

MULTIDISCIPLINARY RESEARCH AND ORGANIZATION

Wherever a research institute is located, certain facilities or certain improvements acquire advantages of convenience, and researchers tend to spend all their time on them. Such a limitation would be a mistake. Grouping is useful, but it should not become a restriction; rather, it should be flexible, and groups should be few enough to arrive at actual solutions. For example, the cropping systems group should work with soil fertility, soil physics, and climatology. Such cocperation is possible only when research and related discussions are problem- rather than discipline-oriented.

The major difficulties to be resolved are the organization of the program, the research philosophy, and the budgeting and staffing criteria and procedures. The proposed Coordinating Unit could be utilized for greater liaison, linkages, feedback, feedforward, etc., both within the FSRP and between the Program and the Institute's crop improvement programs.

There could be two ways of allocating the budget resources: one portion to the purely functional activities in a subprogram, and the other to operational activities, that is, to individual projects.

BENCHMARK LOCATIONS

The location of benchmark sites, and the philosophy behind the benchmark idea need to be considered carefully. Locations should be selected with great care, to be representative of important areas and problems, and they should be correctly characterized. Because budgets are limited, and how much researchers can do so is also limited, it would be easy to spread ourselves too thinly and thus diminish our potential for achievement.

We might be able to find a number of benchmark sites--for example, about 50--that, from ICRISAT's point of view, could be regarded as standard situations for selected SAT regions. Of these, we would then choose no more than five at which to work intensively.

ICRISAT should concentrate on complete case studies, starting with the definition of the problem and following right through to the transfer of technology. Using its computer modeling and other facilities, ICRISAT might provide guidelines for national centers and institutions, where appropriate. We should really be formulating principles to be transferred to the scientific community to work with at other sites.

RELATIONS BETWEEN THE FSRP AT PATANCHERU AND ICRISAT STAFF IN AFRICA

The question of the relationship between the FSRP activities at Patancheru and

farming systems research at the Sahelian and Sudanian research locations in Africa needs to be considered. This relationship should not be substantially different from that of the crop improvement programs in India to those in Africa.

The new Sahelian Center represents an important and carefully chosen benchmark because Alfisols cover substantial regions in the SAT. In Niamey the Alfisols are so sandy that they could almost be called just sandy soils. A socioeconomic typology has not been imposed on this benchmark yet, but we know that it is different from that at Patancheru. These studies will be the whole-time concern of the small farming systems research team in Niger. Participation by other people, who can contribute, is naturally to be encouraged. What we do in Niger will suggest solutions to many important problems encountered in the whole region.

At Kamboinsé the concept of toposequence is relevant; however, the toposequences chosen for research should be predictable across space and not just unique to a single location. This site is not as well chosen as the Sahelian one, though the rainbelt represented by Kamboinsé is an important one.

In southern Upper Volta millet is in many areas more important than sorghum, and it seems necessary to grow millet in shallow upland soils even though neither the shallow soils nor the rainfall is well suited to growing millet.

FARMING SYSTEMS RESEARCH: FUTURE DIRECTIONS

We have learned a lot in the last 8 years, and have made quite a substantial contribution to the world's thinking on farming systems, if not an impact on production systems. We are at a stage now where we want to make a change, but to see where and how we can be more useful to the world community and, particularly, to fulfill the mission for which ICRISAT was created.

A food famine is looming on the horizon in West Africa. Naturally people there are more interested in seeing how we can make an impact quickly on actual production. Likewise, in India, the question is how soon ICRISAT is going to make an impact on actual food production. The highest priority, therefore, is to see if we can help produce a few more million tonnes of food grains in the fields of small farmers.

In relation to resources, two aspects need to be considered. First, we must explore contractual arrangements with other organizations so we can draw on their expertise instead of our expending too much effort in that direction and duplicating the work. Second, we must look at recent changes in international agriculture and see how we can draw upon a funding agency, such as ISNAR, for strengthening national programs so that we can work together.

There is a good deal of agreement on a conceptual framework, and on the need for coordinating FSRP activities. These can now be placed in their proper context in the total network. Other areas need more elucidation--the idea of benchmarks, for example--and we therefore need to spend more time on these.

Some clear problems exist, requiring focus, in relation to soil, climate, and environment. The deep Vertisols form one such group; the Alfisols with clayey subsoils a second; the very sandy soils of the drier SAT a third. But not all our problems are soil- and water-related. It is time now to apply the knowledge we already have, and to consider what additionally needs to be implemented.

The Coordinating Unit should relate both to farming systems research at ICRISAT and to our relationships with other people. Farming systems research is not located within any one program. There are good reasons for that and, of course, researchers in other programs also contribute to research on farming systems.

Finally, it is not organization alone that determines the program's achievements; it is the will and the cooperation of the participants. As repeatedly mentioned during these discussions, a good deal depends on the selection of priorities. This review has demonstrated clearly that this group has the ability to make such a selection. But, in doing so, enough consideration should be given to what will most effectively contribute to an actual increase in production. The ability to adjust as circumstances dictate--especially in the context of funding--should also be maintained. The effective cooperation of the national programs and people is vital to the international centers to reach the producers. Fostering such cooperation is therefore another important consideration in overall planning.

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PARTICIPANTS

Governing Board	C.F. Bentley, Chairman J.L. Dillon, Member G.J. Vallaeys, Member
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O.P. Singhal, Agricultural Engineer
M.V.K. Sivakumar, Agroclimatologist
K.L. Srivastava, Agricultural Engineer
G.E. Thierstein, Principal Agricultural Engineer
T.S. Walker, Principal Economist
R.W. Willey, Principal Agronomist