PN-AAU-330 43367

Proceedings of the

Eastern Africa-ACIAR Consultation on Agricultural Research

Major Agricultural Problems and Research Priorities in the Eastern-Africa Region

Nairobi, Kenya
19-22 July 1983

The National Council for Science and Technology, Kenya
and
The Australian Centre for International Agricultural Research
(ACIAR)

1984

Best Available Document

Concept and Practice of Farming Systems Research

J.L. Dillon and J.R. Anderson*

One could easily gain the impression, given the spate of recent literature, that the farming systems approach to research was only discovered in the past decade or so. Until the 1970s, little was heard of it. Since then it has had no shortage of either powerful proponents or opponents in those various national and international forums where the organization, programming, and budgeting of agricultural research are decided——a sign, no doubt, that farming systems research (hereafter FSR) is significant and revolutionary. Yet, farming systems have necessarily existed since farming began. Likewise, it is inconceivable that agricultural research can ever have been conducted without some appreciation of the farming system context to which it related. Indeed, with hindsight, one may argue that much successful agricultural research historically has been that which was conducted with an implicit farming systems orientation. Nonetheless, it is also a fact that institutional research specifically organized in terms of farming systems is relatively new, dating perhaps from no earlier than the 1950s. Only in the past decade has FSR gained formal recognition via the sanctioning of budget appropriations and designated program activities within a variety of research agencies and in terms of the research literature. For instance, the journal *Agricultural Systems* only began in 1976.

As a formal framework for the conduct of agricultural research, the farming systems approach is still, for many people, ill-defined and unproven. Certainly, being so new in its modern formal incarnation, it is true that the concepts, terms, and methods of FSR are young and evolving. Thus some have found it:

1. To suffer from problems of definition.
2. To involve activities that seem to lack specificity of purpose.
3. Not to have a codified set of methods for its implementation.
4. To involve a bewildering array of activities.
5. To be difficult to evaluate in benefit-cost terms.

Perhaps heroically, against such a background, in this paper we attempt to outline the farming systems approach, appraise its relevance and consider its implications for research organization and management in the context of agricultural development.

The Farming Systems Approach

What is the farming systems approach to research? Certainly it does not imply the use of some new independent science. Rather, it involves the application of knowledge available from the physical, biological, and social sciences (i.e. from the standard pool of knowledge used in traditional agricultural research) but with the difference that it uses a systems approach (Couger and Knapp 1974) in its inquiry. Thus FSR is holistic in outlook and is both multi and interdisciplinary. Reflecting its systems orientation and consequent need for realism and practicality (expressed in part by an understanding of farmers' existing systems), the activities of FSR include both working at the farm level and at the research station level, often with less control than is usual in traditional research with its focus on a particular discipline or commodity.

Basic to FSR is an appreciation of the farm as a system whose *modus operandi* is specified by some particular farming system of which the farmer is an integral part. Defining what is meant by the term 'farming system' is not easy, as is indicated by the following statement (Dillon et al. 1978, p.8.):

> 'A farming system is not simply a collection of crops and animals to

Professor and Head, Department of Agricultural Economics and Business Management, University of New England, Armidale, N.S.W., Australia; Associate Professor, same Department, respectively.

which one can apply this input or that and expect immediate results. Rather it is a complicated interwoven mesh of soils, plants, animals, implements, workers, other inputs and environmental influences with the strands held and manipulated by a person called the farmer who, given his preferences and aspirations, attempts to produce output from the inputs and technology available to him. It is the farmer's unique understanding of his immediate environment, both natural and socio-economic, that results in his farming system'.

More directly, Shaner et al. (1982, p.16) have defined a farming system as:

> 'a unique and reasonably stable[1] arrangement of farming enterprises that the household manages according to well-defined practices in response to the physical, biological, and socio-economic environments and in accordance with the household's goals, preferences, and resources. These factors combine to influence output and production methods. More commonality is found within the system than between systems. The farming system is part of larger systems——e.g. the local community, and can be divided into subsystems——e.g. cropping systems'.

Thus a farming system involves complex interaction between a variety of interdependent components both physical and psychical which, in turn, may often be viewable as subsystems. Central to the system is the farmer himself.

Following Norman (1980), Figure 1 is a schematic representation of the determinants of a farming system. The environment is seen as having two elements; human and technical. The technical element, specified in terms of available technology and climate, defines production possibilities. The human element involves exogenous factors (including the socio-economic and cultural environment) that influence the farmer's decision making as to what farming system he will use in the face of the technical and resource constraints that he faces.

In such terms, FSR can be viewed as research that: (a) views the whole farm as a system; (b) is conducted with a recognition of and emphasis on the interdependencies and interrelationships that exist among elements of the farm system, and between these elements and the farm system's environment; and (c) is aimed at enhancing the efficacy of farming systems through the better focusing of agricultural research so as to facilitate the generation, testing and adoption of improved technology.

To these ends, the major activities involved in FSR oriented to a particular target group or region are:

1. To develop a clear statement and agreement on initial objectives of the team.
2. The collection and analysis of base line data.
3. The study of existing farming systems.
4. The design of new system components, subsystems, and/or farming systems.
5. Farm systems experimentation.
6. The evaluation and monitoring of new components and/or new or modified farming systems.

Some Examples of FSR

The span of application of FSR, ranging from simple system adjustment through revision to replacement by a virtual new system, is illustrated by the following three examples.

1. System Adjustment in Brazil

Wheat, which would otherwise be very well suited, suffers from the high aluminium level of the soil in the Cerrado of central Brazil. Recognizing this, EMBRAPA and CIMMYT are cooperating on a wheat breeding program to develop wheat varieties resistant to aluminium toxicity. When available, this new germplasm will, as a simple adjustment to the prevailing system, replace the existing wheat germplasm

1. A referee has expressed the cogent view that a feature of many farming systems in upland areas (e.g. Ethiopia, Nepal) is that they are becoming inherently unstable under sustained resource 'pressure'.

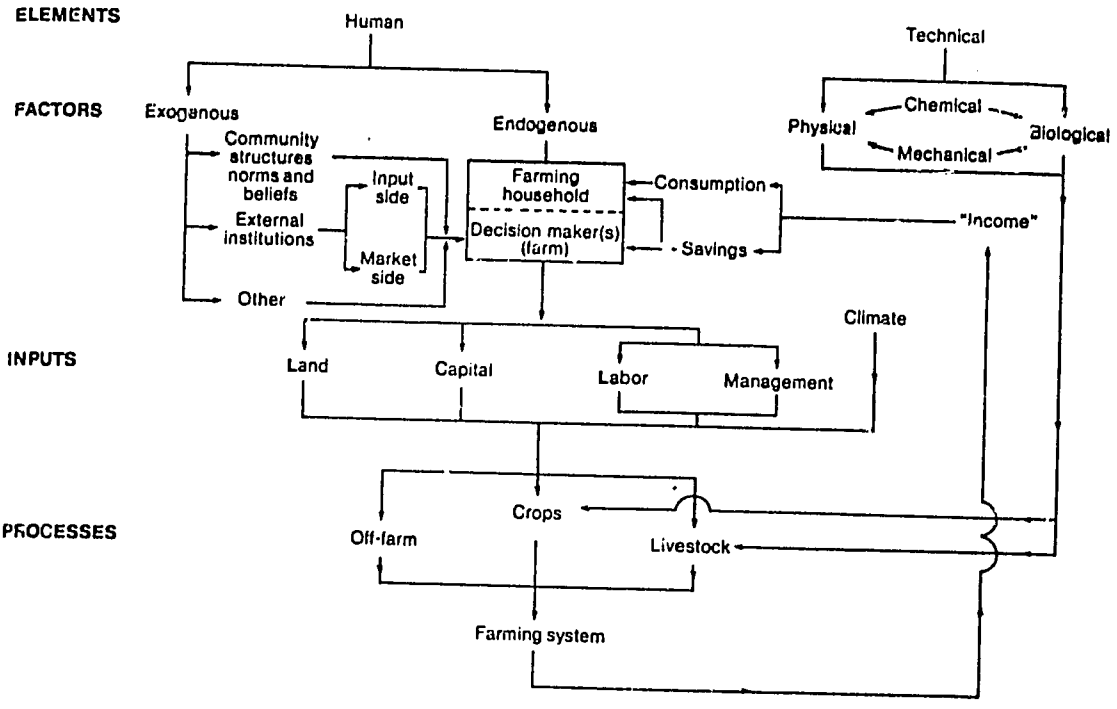

Figure 1. Schematic representation of some determinants of a farming system (After Norman 1980).

From a FSR view, this is not a complicated matter——though the breeding research may be quite complicated (as may also be the research needs opened up when Cerrado farmers, through the income generated from the new wheat germplasm, have the potential for further elaboration of their farming systems).

2. System Revision in the Philippines

IRRI's Cropping Systems Program has focused on rice-based systems of small farmers in rainfed areas. One avenue of assistance to these farmers was seen to be increased cropping intensity (Zandstra et al. 1981). For areas with a growing season of intermediate length, appraisal indicated that the effective growing season might be lengthened. The following methods, either alone or in combination, were proposed: (a) the use of shorter duration varieties, (b) techniques allowing earlier planting at the start of the rainy season, (c) overlapping of growing periods by relay cropping and intercropping, (d) use of drought-tolerent crops, (e) improved soil moisture usage, and (f) use of supplementary irrigation.

Thus, for example, research into rainfed rice systems in the Iloilo region of the Philippines showed that new short-duration rice varieties in combination with direct seeding techniques would enable other upland crops to be planted before or after rice and, in lower-lying areas, the production of two rice crops in a single season. When IRRI began this work in 1975, 82% of the rainfed land in the Iloilo region was planted to a single-crop rice fallow pattern. Today, in contrast, some 75% of the region produces two or more crops per season. With this revision to the farming system, a significant increase in the region's cropping intensity was achieved in two years.

3. System Replacement in India

Perhaps the most significant application of FSR to date has been ICRISAT's development of virtually a new farming system for the Vertisol sub-region of India having a soil depth of at least one metre and a mean annual rainfall above 750

mm. The new system appears suited to implementation on at least 5 million and perhaps as much as 12 million ha of this subregion of 73 million ha in India's semi-arid tropics. Currently, this area of rainfed agriculture is left fallow during the rainy season and cropped for wheat, chickpea, sorghum or safflower in the postrainy season.

The essence of the new system (Swindale 1981; Kampen 1982; Reddy and Willey 1982) is the growing of an extra rainy-season crop on the lands presently left fallow, thereby raising cropping intensity from its present level of around 100% to around 200%. Development of the new system has involved multidisciplinary on-station team research at ICRISAT Center near Hyderabad since 1974. Central to this work has been the use of operational-scale watersheds and subwatersheds of from 1-5 ha in size. The technology options considered have been of a moderate-input nature based on bullock power and, assuming that some economies of size can be achieved in the manufacture of implements, lie within the reach of the small farmer. They are based on the concept of the small watershed as the basic resource management unit. They are technology options that will create employment and are thus socially relevant.

Within the context of the small watershed (which will typically involve some 6 to 20 farmers), components of the new system are (Ryan et al. 1982):

(1) Cultivation of the land immediately after the previous postrainy-season crop when the soil still contains some moisture and is not too hard.
(2) Improved drainage with the aid of field and community channels and the use of graded broadbeds and furrows constructed with a bullock-drawn wheeled tool carrier.
(3) Dry seeding of crops (such as sorghum or maize in a sequential or intercropping system with legumes, such as pigeonpea or chickpea) before the monsoon rains arrive.
(4) The use of improved varieties and moderate amounts of fertilizers.
(5) Improved placement of seeds and fertilizers; and attention to improved plant protection, particularly for legume crops.

While any one of these components, with the exception of fertilizer, gave only a small effect on production, all of them together produced spectacular results. This is shown in Table 1 from Ryan et al. (1982, p.8) for the case of a maize-pigeonpea intercrop system in 1976-77——a system, which in research station trials over the years 1976-77 to 1980-81, gave an average annual yield of 3.85 t/ha of food grain production without irrigation. Economic analysis of these on-station experiments has been made by Ryan and Sarin (1981). The new improved system using all the devised technology gave annual profits averaging US$365/ha, compared with only US$50/ha from the simulated traditional system. The ICRISAT Center study suggests that, for an extra annual cost of US$120/ha, a farmer changing from the traditional to the improved system can earn an additional profit of about US$310/ha per year. This represents a rate of return on the increased operating expenditure of 260%.

To provide on-farm verification of the proposed new system, ICRISAT conducted a farmer-managed trial in 1981-82 in a village chosen to be representative of the deep Vertisol region with assured rainfall. A watershed of some 15 ha involving 14 farmers was used for the experiment. Some assistance by way of wheeled tool carriers, power sprayers and surveying of the watershed was provided but other required resources were paid for by the farmers. Advisory input from ICRISAT scientists amounted to 1.4 man years. The farmers were also guaranteed that they would not earn less than they could have expected by using the traditional system. To this end, nearby plots representative of the traditional system were also monitored. Using information provided by ICRISAT, the farmers made their own crop choices——this resulted in nine different crop combinations, including the crops of one farmer who decided not to change.

The results of this farmer-managed trial have been summarized by Ryan et al. (1982) and Ryan and von Oppen (1983). Averaged over the nine cropping systems on the improved watershed, the profits were US$306/ha compared with US$165 for the traditional system. This implied an average rate of return of 240% on the farmers' extra annual expenditure and confirms the experience at ICRISAT Center (even though atypically high prices for postrainy-season sorghum grain led to unusually high profits in the traditional

Table 1. Synergistic effect of variety, soil management, and fertilizer application in a maize-pigeonpea intercropping system on a deep Vertisol at ICRISAT Center, Patancheru, A.P., India, 1976-77.

Treatment	Yield (kg/ha)	
	Maize	Pigeonpea[a]
Maize variety: Local		
Traditional inputs and management	450	320
With improved soil- and crop-management alone	600	610
With fertilizer application alone	1 900	450
With improved soil-crop management and fertilizer	2 610	840
Maize variety: Improved/hybrid		
Traditional inputs and management	630	500
With improved soil- and crop-management alone	960	640
With fertilizer application alone	2 220	540
With improved soil-crop management and fertilizer	3 470	600
L.S.D. (5%)	470	220

a. Pigeonpea variety was the same in all cases.

system in 1981-82).

As typical of on-farm FSR, particularly when dramatic changes are made to the existing farming system, this farmer-managed trial threw up a variety of problems for further consideration. These included difficulties with *Striga* weed in sorghum, pod borer in pigeonpea, threshing and storage, bullock power availablility, markets for new crops, credit requirements and mechanisms, fertilizer sales distribution, implement availability, and skill development in farmers and extension personnel.

Some of these problems imply further research station trials, others imply policy and institutional considerations. Also, with the extension of on-farm trials to a further eight representative sites involving a total of 57 farmers on 120 ha across the deep Vertisol region in 1982-83 and the implementation of the technology by official agencies in four States in 1983-84 with the development of some 4 000 ha involving 1 700 farmers, there is no doubt that further problems will be discovered.

The Need for a Farming Systems Approach

If agricultural reseach aimed at the improvement of technology is to be fruitful, it must generate knowledge that is actually used by agricultural producers. Otherwise, if the research has no impact, it implies wasted effort and loss of other opportunities (including those foregone because research has earnt itself a bad name).

The need for FSR and its usefulness lie in the degree to which traditional research approaches of a disciplinary or commodity nature fail to produce results that are actually used by farmers. Such failure of traditional research can be usefully related to the FSR concepts of system adjustment, revision, and replacement. Traditional research whose impact, from the farmer's view, is merely system adjustment has *ceteris paribus*, the greatest chance of adoption. Thus we have the success of well adapted new, especially Green Revolution, varieties since they

only require the farmer to make minimal adjustments to his existing farming system. In contrast, system revision is more difficult to implement, and system replacement, from the farmer's view, is the most difficult of all.

Traditional disciplinary or commodity research results whose potential impact lies in system replacement are highly unlikely to be adopted because, by the nature of traditional research, such results will have been generated without due regard to the realities of the farmer's situation and the difficulties he faces in system replacement. Thus it is inconceivable , for example, that the current implementation of ICRISAT's Vertisol technology could have occurred without its having been developed in an FSR context. Indeed, it is most unlikely that a traditional research approach would have been able to generate such a technology.

The results of traditional research may fail to be adopted for two reasons: on the one hand, the research may be misdirected because the researchers misperceive the farmer's situation through lack of understanding of his desires, perceptions (especially of risk) and constraints or, on the other hand, because the farmer cannot perceive the relevance of the research results due to inadequate information. Through its orientation to the farmer, emphasis on the understanding of his existing farming system and its context as its starting point, and its follow-up activities, FSR aims to ensure that these two difficulties are overcome, in turn ensuring more rapid adoption of the new technology that it generates than would otherwise be the case. At the same time, because of its system orientation, FSR is more likely to ensure consideration of the whole system within which agricultural production takes place, and thereby give due weight to both the needs of farmers and of society at large, as well as more effectively identifying and suggesting solutions to institutional constraints to agricultural development.

Without doubt, the greatest need for an FSR approach is in the development of improved technology for the masses of small farmers in the less developed countries. This opportunity arises, first, because such farmers, who are of overwhelming numerical importance in the Third World, generally do not have either the education or information services to enable them to act as good integrators of new scientific information; and, second, because traditional research in such countries (a) has generally overemphasized biological potential and yield consideration without sufficient attention to other relevant criteria, (b) has been based on priorities decided by government or by researchers without the involvement of small farmers, and (c) has been carried out on experiment stations in isolation from small-farmer conditions. To a significant degree, these difficulties reflect the inadequacies of traditional institutional arrangements for agricultural research——a matter to be further pursued below.

To the extent that farmers are capable integrators of new scientific information, have influence in the choice of research that is to be conducted, and rely on sole cropping and monoculture, the need for a formal FSR approach is reduced. There still remains, however, the argument that FSR, by virture of its holistic approach, provides a more complete approach to agricultural research than the traditional disciplinary or commodity approaches with their reductionist philosophy of research (Dillon 1976). Thus it can be argued that most successful agricultural researchers have, in fact, had an appreciation and understanding of the farming systems relevant to their work, even though their research was conducted with a disciplinary or commodity focus.

Methodology of FSR

While there is still much discussion over various points of detail, the general methodological framework of FSR is no longer a matter of contention as evidenced by the general consensus to be found between, for example, Collinson (1982), Dillon et al. (1978), Gilbert et al. (1980), Norman (1980), Shaner et al. (1982) and Zandstra et al. (1981). In this section we follow these authors in suggesting what sould be done in FSR without elaborating precisely how it should be done. There is much ambiguity about tha latter and the unresolved questions about it constitute a prevalent weakness in the practice of FSR.

Following Collinson (1982), Figure 2 depicts the overall framework of FSR. Broadly, seven activities are involved. To a degree, particularly in the initial stages, these activities will be sequentially cyclical as shown in Figure 2. However,

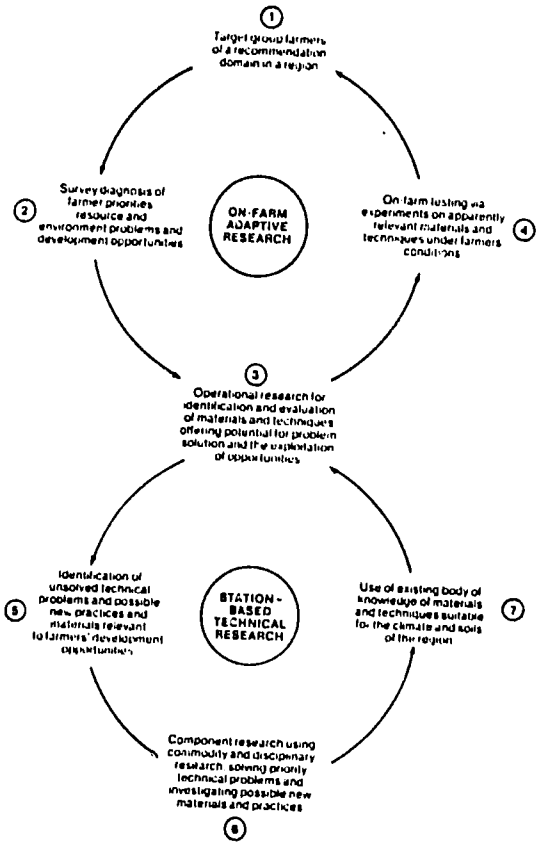

Figure 2. Schematic view of FSR method (After Collinson 1982).

once an ongoing FSR program is established, all the activities will likely be going on simultaneously with forward and backward interactions across them all. Relative to each activity, the following points may be made:

Choice of Target Area or Group

Selection of the target area or group (sometimes referred to as the recommendation domain) should: (a) attempt to be compatible with social needs and priorities, (b) be such as to give a fair chance of obtaining tangible results in reasonable time, and (c) be broad enough to spread costs (Perrin et al. 1976). The most satisfactory delineation is likely to be based on the relative homogeneity of the farming system currently used or, in terms of potential, on the basis of agroclimatic zoning. The aim should always be to strike a satisfactory balance in terms of the economic trade-off between decreased intra-group variability (or increased inter-group variability) and the problem of location specificity, which reduces the domain of impact (Menz and Knipscneer 1981).

Both in the delineation of the target area and in its further specification once chosen, there will be a need for base line data analysis. Time and cost considerations may often imply the use of secondary data. The relevance of data should be judged in terms of their contribution to the delineation and understanding of existing farming systems, their constraints, and opportunities for modification. Base line data will involve both physical factors such as land, soil and climate, and socio-economic factors such as population, culture, and infrastructure. Generally, base line data analysis will be carried out as a desk study. It will, of course, also make use of any micro information that is already available from prior surveys or research into existing farming systems.

Diagnostic Survey

Having delineated a target area or group, it is necessary to gain an understanding of the existing farming systems and farmers' motivations in using them. The main aim of this activity is to provide an assessment of farmers' priorities, decision criteria, resource availabilities, constraints, and possible development opportunities. The survey will also, if need be, provide a basis for delineating separate recommendation domains of farmers within the overall target area group. These domains may be based on natural factors such as soil or topography; cultural factors such as food preferences; or institutional factors such as tenure and market access.

Two broad types of surveys have been used for diagnostic purposes, i.e. reconnaissance or exploratory surveys, and formal surveys (Byerlee and Collinson 1980; Byerlee et al. 1980; Gilbert et al. 1980). The former are relatively informal and of low cost. They typically involve a week or so of field travel through the target area by a small multidisciplinary FSR team (e.g. an agronomist and an economist) who talk with representatives of policy-making and farmer-contact agencies, community leaders, and a small sample of farmers and their families. Formal surveys, in contrast, typically involve some considered form of sampling and prespecified sample sizes,

designed questionnaires and an orientation to traditional scientific standards of accuracy. In contrast to informal exploratory surveys, they are likely to be time consuming and costly. This will be particularly so if the formal survey is of a multi-visit panel nature with field recording of production factors.

If time and resources permit, and the need is seen, both exploratory and follow-up formal surveys will be conducted. In terms of gaining an understanding of existing systems and opportunities for change, they are complementary and perhaps best seen as relating to different stages of an FSR program. Initially, the rough and ready information of an exploratory survey may suffice; later, particularly if systems modelling (e.g. mathematical programming analysis) is used, more detailed information obtainable only via formal survey procedures may be needed.

Identification of Possible Changes and Operational Research

From appraisal of the survey information (and also from operational research), judgements can be made as to system changes that might be feasible and relevant. This experiment-station (or sometimes farmer's-field) based design, and operation research activity should generate a few sets of improved practices for possible testing at the farm level and suggest a number of technical problems or more major system changes needing deeper research. More risk-averse researchers may want more rather than a very few sets.

Criteria suggested as relevant (Gilbert et al. 1980) to the initial choice of possible changes for farm-level testing have been that they:

(1) Involve, as experimental variables, practices in which farmers' management is flexible (perhaps due to underutilized resources) and where *ex ante* evaluation suggests the possibility of increased productivity (perhaps due to limiting resources).

(2) Assume few changes in the existing institutional framework relating to input supply and product marketing.

(3) Take as parameters in the experimental process those factors not potentially subject to manipulation, their level being set so as to be as representative as possible of practical farming conditions.

In the longer term, more drastic system changes become more feasible and the above strictures may be relaxed.

The design stage of identifying possible system changes for on-farm testing may involve experiment station trials of an operational research nature and should always involve *ex ante* economic appraisals as, for example, discussed by Anderson and Hardaker (1979), Banta (1982), Ghodake and Hardaker (1981), and Ryan et al. (1979). Generally, the greater the body of existing knowledge pertinent to the system under study, the shorter will be the time required on the experiment station to complete the design stage and the more valuable is panel survey work.

System changes considered at the design stage may involve incremental or 'single trait' changes or more extensive 'packages' of practices. While incremental changes are doubtless easier to design and extend, packages will often have the advantage of capturing complementary or synergistic effects between components.

On-farm Testing

Farm-level evaluation via both researcher-managed and farmer-managed trials is a crucial element of FSR methodology. The evaluation criteria should be the same as those used by farmers, whatever they may be, as ascertained in the diagnostic survey. Performance of the improved technology, of course may drop as it is moved from the artificial conditions of the experiment station to the farm level, particularly under farmer management where it is being fully tested for compatibility with the existing system.

Research-managed farm trials can cover more treatments than farmer-managed trials and should be aimed to screen proposed technologies from the design or experiment-station stage, to fine-tune them to local conditions, and to evaluate their potential for local and regional coverage. All this is, of course, easier said than done, and refinement of the operational details for successful practice remains the key challenge in FSR.

Farmer-managed trials are the strongest form of testing. These trials should be on sufficiently large plots and involve as many farmers on a continuing basis as is practicable to provide valid information on the new technology itself and on

its compatibility with other parts of the farmer's system, and should be replicated over time with any modifications deemed necessary from the ongoing appraisal.

Choice of farms for farm-level testing is important as it bears on the question of farmer-research team interaction and technology transferability. To foster transferability, sites should, if possible, be representative of large areas, particularly with regard to landscape position. To foster farmer-researcher interaction, the more cooperative better farmers will tend to be preferred as collaborators. However, these are not representative farmers. Use of 'average' farmers, while decreasing interaction, may give a more satifactory appraisal of the proposed system changes.

Associated with and growing out of the on-farm testing activity are extension, monitoring, and evaluation activites. Extension workers should be involved directly in the on-farm testing activities so as to be fully informed. They, along with other member of the FSR team, should monitor the spread and evaluate the performance of the newly introduced technology so as to provide feedback to policy makers and sponsors, if there are any, on any relevant issues. In this sense, monitoring and evaluation should be made from the various perspectives of farmers, researchers, and society as a whole.

Identification of Technical Problems

Arising out of the diagnostic survey and identification of possible system changes, a variety of technical problems (e.g. diseases, market difficulties, etc.) can be identified. The feasibility, potential benefits and priority of attacking these problems need to be established as a prior step to undertaking research aimed at their solution.

Component Research

Having decided on the portfolio of technical problems to be researched at greater depth, commodity or disciplinary research on the relevant system components can be conducted on the research station. This research may be oriented to single or multiple components and may involve quite basic research, although to ease subsequent transfer, conduct on farms will be preferred where possible.

Single component research, which aims at improving individual components, will generally help elucidate 'principles' and 'processes'. It includes such topics as, e.g. identifying suitable genotypes for a particular cropping system, examining factors effecting runoff, etc.

Multi-component research constitutes the initial integration of modified or new components developed from disciplinary research into the system. It includes aspects such as the integration of cropping systems with labour availability, soil fertility management, and watershed management.

Use of Existing Scientific Knowledge

Particularly in the experiment station sequence from component research to operational research, use will be made of the existing body of scientific knowledge of both a general nature and specific to the target area or group and its farming systems.

Organization of FSR

The broad organizational lines of FSR spanning on-farm adaptive ('downstream') research and station-based technical ('upstream') research are depicted in Figure 2. Much debate has occurred over the separation and overlap of these activities——see, e.g. Dillon et al. (1978), Norman (1980), and Gilbert et al. (1980). Such debate, however, has been rather fruitless. A complete FSR approach will involve full integration of on-farm and station-based research with the same researchers working, as appropriate, in both activities. Thus ICRISAT, for example, has emphasized the complete integration of on-farm and station-based research via its designated Farming Systems Research Program which, as shown in Figure 3, exists alongside and interacts with the ICRISAT commodity (germplasm) and economics programs (ICRISAT 1983). A similar approach has been taken at ICARDA.

Compared with a traditional organization of research on the basis of disciplines and/or commodities, FSR has strong implications for research organization and management.

By virtue of its holistic approach to the problems of agricultural production, FSR is mul-

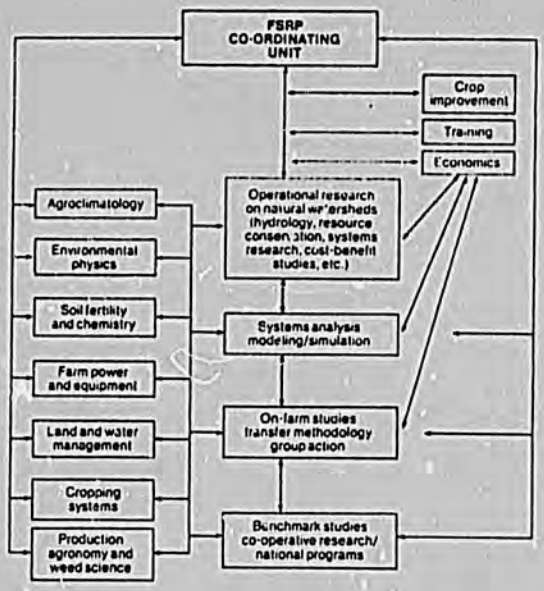

Figure 3. Organization chart of ICRISAT's Farming Systems Research Program (After ICRISAT 1983).

tidisciplinary in nature. It should be organized so as to provide a means by which multidisciplinary teams of researchers can examine problems of the relevant farming systems, including the complementary and competitive relationships between enterprises. The characteristics of FSR thus transcend those of conventional disciplinary research, in that FSR through a multidisciplinary team effort with a systems orientation, aims to develop new technology that is compatible with farmer goals and that will enhance system productivity.

The organization of FSR should thus be such as to encourage effective interdisciplinary interaction, which is the key element in FSR and is best encouraged by purposive leadership and voluntary cooperation rather than by attempted institutionalization through structure and formalities. Flexible procedures and mechanisms have to be developed to facilitate interdisciplinary research. Individual initiative in the competition for ideas should not be sacrificed. Sharing of experiences through networks can be very helpful and, as IRRI has shown through its cropping systems research network, can be especially useful in training FSR workers.

The successful operation of FSR programs places great demands upon the scientists involved. Coordination must be frequent and be undertaken by the people directly concerned. Team work is essential. Most importantly, the intra-institute organizational structure for FSR must be flexible; as the research task changes, so too, if need be, should the team and its leadership also change. Team leadership should not respect seniority. A high standard of professionalism is required which, in turn, requires that personal professional goals must be realizable within the system and the team.

One implication unique to FSR is that scientists should be involved in all steps of agricultural research. Scientists do not stop at one stage and hand over their research product to someone else for its further development and testing, but rather should participate in all stages of the problem-oriented research. Research with a conventional approach is usually much more compartmentalized across time and space.

At the more macro institutional level, the implementation of farming systems approach implies significant changes to the organizational structure of research found in many developing countries. First, it implies a shift away from commodity or disciplinary-based research institutes or divisions to a multidisciplinary farming systems orientation. In many countries this would perhaps be best expressed by a shift away from a system of research institutes or stations each having responsibility for a specific commodity to a system emphasizing regional responsibilities (but within which, of course, component research would still be undertaken as needed). Second, it implies a high degree of flexibility in the research, with considerable devolution of decision making and responsibility to those actually doing the work. Third, it implies a far higher degree of integration between research and extension activities than is usual. Extension personnel should be part of the FSR team and, ideally, there should be no institutional break between research and extension. Otherwise, the adoption of an FSR approach may lead to a new set of extension activities being carried out, and the consequent isolation of the traditional extension agency. Fourth, FSR implies a far greater role for farmers, through both formal and informal avenues, in the determination of research agendas. Fifth, through its orientation to farmer reality and the total environment of agricultural production, FSR implies an integral role for social

scientists, particularly agricultural economists, in its activities. So important and so often misunderstood is this role that we take it up separately.

FSR and the Social Scientist

In the post-euphoric phase of the Industrial and Green Revolutions, the importance of human, social, and economic factors in farming systems is so widely recognized that it does not need further elaboration here. Research administrators, whether they be in regional, national, or international organizations have generally responded by ensuring that social scientists are represented in research structures.

The form of their representation varies widely, reflecting such things as the prejudices of the administrators and their influential scientific advisers (especially from other than the social sciences) and the availability of social scientists with backgrounds and interests in agriculture. The range extends from a token and peripheral appointment or two, through specialized service divisions of social sciences, to complete integration of social scientists in multidisciplinary research and problem-solving teams. In spite of the diversity, we might chance the generalization that the institutional incorporation of social scientists becomes more haphazard, the more local is the level of organization. Thus, for example, social scientists are pervasively involved in the International Agricultural Research Centres but, at the other extreme, can be almost nonexistent at the regional agricultural research stations of the Third World where priorities have usually been given to activation of biological research. Perhaps it is the political sensitivity of socio-economic research findings (e.g. on income distribution issues) that have slowed the advancement of social sciences in Third World agricultural research[2]. Fortunately, however, the situation is improving rapidly in most such countries.

What is it that social scientists have to offer in farming systems research? Surely, it is not simply informing someone that beans have a higher market price than barley, or working out costs of production! It can be many things, and will doubtless vary from scientist to scientist, accordingly to disciplinary training and experience. Among the most important matters that will be addressed are: (a) the social milieu in which farm decisions are made, including customs of sharing and bequest, (b) the institutional setting and policy environment in which farming is conducted, including land reform, credit, and taxation, (c) the economic environment of farms, including long-term market prospects for inputs and outputs and, most importantly, an understanding of the opportunity costs and transactions costs faced by farmers, and (d) the attitudes and personal constraints of farmers, including their desire or otherwise for change, for leisure, for education, for different foods, and so on, and their human and other capital.

Data on such matters are not assembled for their own sake nor for the professional gratification of the social scientists concerned. Rather, the purpose must be to assist in the identification of effective changes to and designs of practices, techniques, enterprises, activities and policies that are acceptable to and appreciated by the target groups in FSR. The days of the 'quick' technological 'fix' have probably gone and progress now must be won in the context of the full reality.

Understanding the wider reality of farming systems does not come easily. Ideally, social scientists glean their knowledge of such systems through long and close contact with the people of the systems. Horton (1983) documents such a recent successful endeavour in Peru. The ideal, however, rarely obtains and more formal methods of description and understanding must be sought. The most widely used approach is a survey that garners detailed information on what happens in the village and on farms, to whom and when. Profiles of labour availability, cash flow, work demands, prices received, etc, can be built up in this way and, if the collections run for a sufficiently long period, the variability over time, especially in reponse to natural hazards like flood, drought and fire, can also be quantified.

Many elements sought in survey activities are subtle and/or sensitive. Particular skills are required to ensure faithful description of reality. For instance, some transactions costs such as bak-

2. A referee has suggested another possibility, namely, that biological science administrators see a contribution from social scientists as being less useful than that from biological scientists!

sheesh to public irrigation managers or to fertilizer distributors may not be readily forthcoming in simple interviews but may involve considerable inflation of factor costs. Production levels may be systematically understated if farmers fear linkage between FSR workers and taxation authorities. For a final example, attempts to elicit information on farmers' attitudes to risk are fraught with the danger of interview bias clouding the sought information. Such anecdotes underscore the costs of reliable FSR survey work. In short, it is (a) time consuming, involving repeated contact both to develop confidence on the part of farmers and to gain an understanding of intertemporal effects, and (b) demanding of a high degree of professionalism on the part of those in direct contact with the farmers. Senior social scientists themselves must be actively involved in the direct contact, even if this is (perhaps linguistically) difficult. Minimally, interviewers should be conversant with the theoretical underpinnings as well as the empirical applications of the collected data.

The roles charted above for social scientists in FSR could be interpreted as a blueprint for integrative scientific supermen and it is as well to reflect on just how well such roles are executed, at home and abroad. To focus on Australia for the moment, a distinguishing feature of most social scientists engaged in work that could be broadly described as FSR is their basic facility in the technology of agriculture. Following British tradition, most of them have a first degree in agricultural science (or agricultural economics), which makes for their ready appreciation of the technical issues in FSR, as well as predisposing more ready peer acceptance from their colleagues in physical and biological sciences. This contrasts with, say, the situation in the U.S.A. where most economists, sociologists, etc. who work in agriculture do not have the same sort of background in agricultural sciences, and may explain, in part, the fairly high proportion of Australians among FSR social scientists working in the International Agricultural Research Centres.

On the organizational side, FSR-type work is conducted primarily in the Australian State Departments of Agriculture. These are partitioned into research and extension units and the structure of research is typically on disciplinary lines. However, there is usually a high degree of collaboration across disciplines, and between research and extension workers. Sometimes the cooperation is formalized in problem-solving teams but usually it works from bottom-up joint activities—especially at regional research centres. Such free-wheeling farm-level interdisciplinary research contrasts strongly with the prevalent arrangements and practices in most African countries, for example, where typically research agencies are rigidly structured and administered so that there is little collaboration between social and other sciences, and extension services are relatively weakly staffed and are bureaucratically and operationally divorced from the research agencies.

Given the rigidity of African bureaucracies, perhaps the best way to foster FSR generally, and its social science components in particular, is to introduce new bureaucratic entities such as 'FSR Coordination Units' wherein the leads being facilitated by, say, CIMMYT in East Africa, ILCA in Ethiopia, and ICARDA in Tunisia might be implemented in national programs of rural research and extension.

Problems in Adopting the FSR Approach

A variety of problems must be met in implementing the FSR approach. First, commitment of scientists to the approach is essential. To be effective and to 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.

Second, 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. Because most agricultural research units are shortstaffed, the temptation may be merely to shift 'conventional' researchers to an FSR group without restaffing the more conventional disciplinary areas. This 'robbing Peter to pay Paul' philosophy should be avoided if at all possible, even granted the shortage of research resources in developing countries.

Third, there may be problems relating to the evaluation and reward of scientific merit. Con-

ventional evaluation and reward systems that do not adequately recognize the scientific ability of an individual in terms of his or her contribution to the achievement of group, rather than individual research, are not conducive to integrated research of the type required in FSR.

Fourth, there may be problems of definition and focus. In its efforts 'to do good', FSR may run the risk of becoming too loosely focused and degenerate into overly site-specific research characteristic of 'rates and dates' agronomy. At the other extreme, as exemplified by Nielsen and Preston (1981), FSR may be excessively systematic and attempt to design ideal farming systems that have little probability of adoption. A practical farm-oriented perspective has to be maintained throughout the conduct of FSR. As already noted, the difficulty of implementation increases significantly as the research orientation moves from system adjustment, to revision, and to replacement. Concomitantly, the development of completely new systems will be much more demanding of research resources and a far more difficult research task than the development of system adjustments or revisions.

Fifth, there is the question of who sets research priorities and for whom. The establishment of formal forums for the interchange of ideas for setting up research priorities and discussion of multidisciplinary tasks is essential. Determination of priorities is not an easy matter and the scientific staff must be well informed if they are to participate effectively in the decision-making process. There may be political obstacles to overcome in some instances, since some governments maintain a deliberate bias against some groups, e.g. against small farmers outside cooperative groupings. If resource reallocation should become necessary, extensive background briefings will be needed. As noted above, it may be necessary for an institution to establish a coordinating unit for its FSR. The functional nature and composition of such a coordinating unit need to be clearly defined. Steps should also be taken to ensure effective liaison and equilibrium between any such FSR coordinating unit and the subject matter areas of research. The unit should continuously evaluate the present status of the FSR multidisciplinary effort and formulate goals and priorities for the immediate future. Additional means to assist this unit may be required.

Sixth, established reward systems based on equating only reductionist activity with good science may cause difficulty. In the context of FSR, such difficulties are aggravated by problems associated with multidisciplinary targeted research. Reporting and presentation of FSR data tend to follow a step-by-step and seemingly fragmented structure that often times provides little stimulation for evaluating the integrated results of the program as a whole. No doubt due to the relative newness of FSR, there are as yet an insufficient range of forums for presentation, discussion, and evaluation of FSR research. It also seems that insufficient importance is attached by FSR workers to such activities. All members of multidisciplinary research teams must be especially cognisant of the need to accord recognition to those who contribute to the scientific success of such teams. Clear guidance for administrators that effective participation in multidisciplinary projects is recognized would seem to be very important.

Seventh, in terms of implementation problems, there is the question of whether FSR can be superimposed on an existing conventional program. The answer is definitely yes. FSR and conventional research are not mutually exclusive. They are complementary, as implied in Figure 2. To be successful, any FSR program requires both basic and applied research. Conventional research programs are often 'project-oriented' or 'departmental-oriented' with individual scientists attached to each department carrying out a specific piece of disciplinary research relevant to the project under consideration. In this approach, which is akin to component research in FSR, individual components are not, however, defined relative to some holistic view. FSR would enable such precise definition and provide for time-bound achievable goals. However, the following organizational needs related to the structure and conceptual framework of FSR should be clearly understood:

1. There should be a satisfactory mechanism for establishing the goals, priorities and allocation of resources within the FRS program.
2. The definition and coordination of research activities, particularly those of an integrated nature, designed to meet FSR goals should be as complete as possible.
3. Sufficient flexibility to respond to chang-

ing circumstances and the introduction of new ideas should be well ensured.

4. Adequate encouragement of activities and communication among subdisciplines, and between FSR and other major activities of the institute, is desirable and necessary.

In terms of introducing the FSR approach into a conventional research institute, the best first step would probably be to introduce or foster on-farm testing as a normal activity of researchers, perhaps through encouraging them to take greater interest in work outside their particular specialities. The second step would be to provide a flexible institutional structure within which researchers can come together to tackle problems on a systematic basis. The third step could be to provide locii for base line analysis, base line surveys and diagnostic research which, along with on-farm testing, would generate enhanced awareness of the need for a FSR approach.

Finally, in terms of implementation problems, some points of caution are necessary. First, it must be recognized that FSR is, to a greater or lesser degree, location-specific (Kalirajan 1981; Menz and Knipscheer 1981). The more complex the system under study, the more location-specific it is likely to be. The constraints defining location-specificity are physical, biological, economic, and social. Physical and biological constraints are the most intractable. They define the limits of improvement that are possible. To define these limits, to assess physical location-specificity and to enable technology transfer, certain minimum sets of data must be obtained on-station and on-farm. Social and economic constraints are less intractable than resource constraints and are more time-dependent. Second, multidisciplinary research can tend to 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 and at the right speed. Third, and most important of all, it must be recognized that FSR is no more than one of many facilitators to development. Of itself, it is not a panacea.

With particular reference to African farming systems, two features of most systems contribute to their complexity in a very significant way. It happens that they are both strongly paralleled in most Australian farming systems so that Australian experience and expertise may have particular value in collaborative work. First, livestock play a central and pervasive role in the functioning and success of such systems. Second, climatic variability (especially rainfall amounts and inter-temporal distribution) is high on world standards, (but not Australian). Witness the present devastating drought affecting southern Africa.

The conjunction of these features is a greatly under-researched field. FSR workers face the prospect of many surprises and insights as they untangle and comprehend the many complementary interactions among livestock and cropping activities and the buffering effects that these have in assisting farmers to cope with turbulence in their environment, whether it arises from natural, economic, or political sources. One of the challenging aspects of such work is to discover and deal with the attitudes towards risk, food insecurity, and wealth held by African farmers. These must be understood much better than they presently are before investigators could, with any confidence, presume to propose 'improved' tactics and strategies for farmers managing in such highly variable environments.

Perhaps the greatest single problem in FSR for Africa, and, indeed, for any alternative model of agricultural research, is the diversity of farming systems. We have alluded to this above in the context of location-specificity. Another issue for researchers to grapple with is the allocation of their scarce investigatory resources among so many competing systems of diverse importance, especially when importance is judged by such things as the contribution to the economic growth and welfare needs of more or less neglected groups. We know of no easy solution to this difficulty but, minimally, research decision-makers must be sensitive to the tendency to concentrate resources on farm people already favoured relative to those in less accessible areas. The price of social relevance may be that work that is more difficult and less scientifically satisfying should take precedence over opportunities that are easier and more comfortable. Special funding may be required in some instances and, with the growing recognition of FSR among donors, this may be increasingly obtainable.

Summary

The FSR approach can be summarized (Shaner et al. 1982, p.4) as farmer based, problem solving, comprehensive, interdisciplinary, complementary, iterative and dynamic, and socially responsible. It is:

1. Farmer based because FSR teams seek an understanding of farmers' conditions and integrate farmers into the research and evaluation process.
2. Problem solving in that FSR teams seek researchable problems and opportunities for improving existing farming systems.
3. Comprehensive in that FSR teams consider the whole farming system in the context of all its environmental influences so as to learn how to improve the farmer's welfare while evaluating results in terms of both farmer and societal interests.
4. Interdisciplinary in its team approach involving scientists and extensionists with different disciplinary backgrounds who work together to identify problems and opportunities, to search for solutions, and to implement and monitor the results.
5. Complementary because it draws on and feeds back to disciplinary and commodity-based research.
6. Iterative and dynamic in that FSR follows a cyclical pattern of research and testing that leads on to further research and testing.
7. Socially responsible in that FSR teams aim to keep public interests, both present and future, in mind, as well as those of the farmer whose farming system is being studied.

Many of these features are, of course, common to the more traditional approaches of disciplinary and commodity research. The combination of them all, however, distinguishes the FSR approach.

References

ANDERSON, J.R., and HARDAKER, J.B. 1979. Economic analysis in design of new technologies for small farmers. Pages 11-26 in *Economics and the design of small-farmer technology*, eds. A. Valdes, G.M. Scobie and J.L. Dillon. Ames: Iowa State University Press.

BANTA, G.R. 1982. Asian cropping systems research: Microeconomic evaluation studies. Ottawa: IDRC.

BYERLEE, D., and COLLINSON, M.P. 1980. Planning technologies appropriate to farmers——concepts and procedures. El Batan, Mexico: CIMMYT.

BYERLEE, D, HARRINGTON, H., and MARKS, P. 1980. Farmers' practices, production problems and research opportunities in barley production in the Calpulalpan-Apan Valley, Mexico. El Batan, Mexico: CIMMYT.

COLLINSON, M.P. 1982. Farming systems research in Eastern Africa: The experience of CIMMYT and some national agricultural research services 1976-81. East Lansing: Michigan State University International Development Paper No. 3.

COUGER, J.D., and KNAPP, R.W. (Eds) 1974. *Systems analysis techniques*. New York: Wiley.

DILLON, J.L. 1976. The economics of systems research. *Agricultural Systems* **1**: 5-22.

DILLON, J.L., PLUCKNETT, D.L., and VALLAEYS, G. 1978. Farming systems research at the international agricultural research centers. Washington, D.C.: Technical Advisory Committee, Consultative Group for International Agricultural Research, World Bank.

DILLON, J.L., and VIRMANI, S.M. 1982. The farming systems approach. Chapter 7 in *Agro-research for Australia's semi-arid tropics*, ed. R.C. Muchow. Brisbane: University of Queensland Press. (in press).

GHODAKE, R.D., and HARDAKER, J.B. 1981. Whole-farm modeling for assessment of dryland technology. Patancheru P.O., A.P., India: ICRISAT Economics Program Progress Report 29.

GILBERT, E.H., NORMAN, D.W., and WINCH, F.E. 1980. Farming systems research: A critical appraisal. East Lansing: Michigan State University Rural Development Paper No. 6.

HORTON, D.E. 1983. Social scientists as agricultural researchers: Lessons from the Montaro Valley Project. P.O. Box 5969, Lima, Peru: CIP.

ICRISAT 1983. ICRISAT farming systems research: A special report. Patancheru P.O., A.P., India: ICRISAT.

KALIRAJAN, K. 1981. The contribution of location specific research to agricultural productivity. *Indian Journal of Agricultural Economics* **35**: 8-16.

KAMPEN, J. 1982. An approach to improved produc-

tivity on deep Vertisols. Patancheru P.O., A.P., India: ICRISAT Information Bulletin No. 11.

MENZ, K.M., and KNIPSCHEER, H.C. 1981. The location specificity problem in farming systems research. *Agricultural Systems* **7**: 95-103.

NIELSEN, J.J., and PRESTON, T.R. 1981. The integrated family farm system for agriculture, livestock and energy production with multipurpose crops, multipurpose animals, ponds with plants and a digester unit for control of both human and animal diseases. Copenhagen: Danish International Development Agency.

NORMAN, D.W. 1980. The farming systems approach: Relevancy for the small farmer. East Lansing: Michigan State University Rural Development Paper No. 5.

PERRIN, R.K., MOSCARDI, E.R., WINKELMANN, D.L., and ANDERSON, J.R. 1976. From agronomic data to farmer recommendations: An economics training manual. El Bataan, Mexico: CIMMYT Information Bulletin 27.

REDDY, M.S., and WILLEY, R.W. 1982. Improved cropping systems for the deep Vertisols of the Indian semi-arid tropics. *Experimental Agriculture* **18**: 277-287.

RYAN, J.G., and VON OPPEN, M. 1983. Assessment of impact of deep Vertisol technology options. Patancheru P.O., A.P., India: ICRISAT.

RYAN, J.G., and SARIN, R. 1981. Economics of technology options for deep Vertisols in the relatively assured rainfall regions of the Indian semi-arid tropics. Pages 37-57 *in* Proceedings of the seminar on management of deep black soils for increased production of cereals, pulses and oilseeds, New Delhi, 21 May 1981. New Delhi: Ministry of Agriculture/ ICAR/ICRISAT.

RYAN, J.G., SARIN, R., and PEREIRA, M. 1979. Assessment of prospective soil-, water-, and crop-management technologies for the semi-arid tropics of peninsular India. Pages 52-72 in *Socioeconomic constraints to development of semi-arid tropical agriculture*, eds. J.G. Ryan and H.L. Thompson. Patancheru P.O., A.P., India: ICRISAT.

RYAN J.G., VIRMANI, S.M., and SWINDALE, L.D. 1982. Potentials and challenges for increased income from deep black soils in relatively dependable rainfall regions of India. Patancheru P.O., A.P., India: ICRISAT.

SCHULTZ, T.W. 1979. The economics of research and agricultural productivity. Washington, D.C.: IADS Occasional Paper.

SHANER, W.W., PHILIPP, P.F., and SCHMEHL, W.R. 1982. *Farming systems research and development: Guidelines for developing countries*. Boulder: Westview Press.

SWINDALE, L.D. 1981. A time for rainfed agriculture. Patancheru, P.O, A.P., India: ICRISAT/Coromandel Fertilizers Ltd.

ZANDSTRA, H.G., PRICE, E.C., LITSINGER, J.A., and MORRIS, R.A. 1981. A methodology for on-farm cropping systems research. Los Banos, Philippines: IRRI.