BIBLIOGRAPHIC DATA SHEET	1. CONTROL NUMBER PN-AAJ-526	2. SUBJECT CLASSIFICATION (695) TC00-0000-0000

3. TITLE AND SUBTITLE (240)

Planning technologies appropriate to farmers: concepts and procedures

4. PERSONAL AUTHORS (100)

5. CORPORATE AUTHORS (101)

Int. Maize and Wheat Improvement Center

6. DOCUMENT DATE (110)	7. NUMBER OF PAGES (120)	8. ARC NUMBER (170)
1980	77p.	6ØØ.I61

9. REFERENCE ORGANIZATION (130)

CIMMYT

10. SUPPLEMENTARY NOTES (500)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

Appropriate technology
Manuals
Planning
Questionnaires
Data collection
Agricultural planning
Technology transfer
Technology choice
Research
Surveys
Farmers

13. PROJECT NUMBER (150)

931084000

14. CONTRACT NO.(140)

AID/DSAN-G-0216

15. CONTRACT TYPE (145)

16. TYPE OF DOCUMENT (160)

AID 590-7 (10-79)

600
I61

N-[redacted]J-[redacted]

PLANNING TECHNOLOGIES APPROPRIATE TO FARMERS

Concepts and Procedures

ECONOMICS PROGRAM
CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIG
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTE
Londres 40, Apdo. Postal 6-641, México 6, D.F., México

PLANNING TECHNOLOGIES APPROPRIATE TO FARMERS

Concepts and Procedures

Economics Program
CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO 1980
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER
Londres 40, Apartado postal 6-641, México 6, D.F., México.

table of contents

PREFACE **What this Manual is About, 1**
The Need for New Procedures, 1
A Preview of the Manual, 2
A Note to the User, 2

PART I — THE FARMER AS THE PRIMARY CLIENT OF AGRICULTURAL RESEARCH, 3

CHAPTER 1 **Overview of Research Procedures to Develop Technologies for Farmers, 3**
On-Farm Research, 4
Experiment Station Research, 5
Policy Context of Agricultural Research, 6
The Place of this Manual in the Overall Research Procedures, 6

CHAPTER 2 **Farmer Circumstances as a Basis for Planning Research, 8**
Definition of Farmer Circumstances, 8
Decisions Required for Planning an On-Farm Experimental Program, 10
Grouping Farmers into Recommendation Domains, 10
Identifying Farmers' Problems and Prescreening Technological Components for On-Farm Experiments, 11
Establishing Representative Practices and Sites for On-Farm Experiments, 11
Identifying Problems for Experiment Station Research and Policy, 11

CHAPTER 3 **A Checklist of Information on Farmer Circumstances, 13**
Natural Circumstances, 14
External Socio-Economic Circumstances, 15
Resource Constraints, 16
Farmers' Goals, 16
Farming System Interactions, 17
Description of Farmers' Technology for the Target Crop, 18
Identification of Limiting Factors, 18

PART II — PROCEDURES FOR OBTAINING INFORMATION ON FARMER CIRCUMSTANCES, 20

CHAPTER 4 **Overview of the Procedures, 20**
Sources of Information on Farmer Circumstances, 20
A Sequence of Steps, 21
Defining the Target Region, 22
Implementing the Research Procedures, 22
Adjusting the Procedures to Fit the Researchers' Circumstances, 22

CHAPTER 5 **Assembling Background Information, 24**
Sources of Secondary Information, 24
Analyzing Secondary Information, 24

CHAPTER 6 **The Exploratory Survey, 26**
The Role of the Exploratory Survey, 26
The Exploratory Survey Process, 26
Assembling Information in the Exploratory Survey, 28
Integration and Evaluation of the Exploratory Survey Data, 29

CHAPTER 7 **The Formal Survey—Questionnaire, 33**
General Rules for Developing a Questionnaire, 33
General Guidelines for Asking Questions, 34
Guidelines to Obtaining Specific Types of Information, 36
Finalizing the Questionnaire, 43

CHAPTER 8 **Sampling for the Formal Survey, 44**
Stratification, 44
Random Sampling Procedures, 45
Sample Size, 46
Non-Response, 47

CHAPTER 9 **Implementing the Formal Survey, 48**
The Interviewer, 48
Gaining Farmers' Cooperation, 49
The Interview, 49
Supervision, 51

PART III — USING A KNOWLEDGE OF FARMER CIRCUMSTANCES TO PLAN CROP RESEARCH, 52

CHAPTER 10 **Analyzing the Survey Data, 52**
Refining Recommendation Domains, 52
Assembling Information on Farmers' Practices, 53
Diagnostic Analysis of Farmer Circumstances, 56
Methods for Tabulating Information, 57
Weighting Procedures, 58

CHAPTER 11 **Prescreening Potential Technological Components, 61**
Limiting Factors, 61
Alternative Solutions to Limiting Factors, 62
Farmers Changes from Using Technological Components, 63
Economic Costs and Benefits of Potential Technological Components, 63
Matching Potential Technological Components to Farmer Circumstances, 64

CHAPTER 12 **Examples of Planning On-Farm Experiments**
Planning On-Farm Experiments for Maize in East Africa, 67
Planning On-Farm Experiments for Maize in the Andean Region, 68
Guiding Research on Tropical Maize Varieties in Dry Areas of Eastern Africa, 68

GLOSSARY OF TERMS, 70

preface: what this manual is about

We have prepared this Manual for professionals involved in research on improving agricultural technology for farmers. We believe that it will be useful to both biological scientists and social scientists and that parts of the Manual, especially Chapters 1, 2, 4, 11, and 12 will also be of interest to those who administer agricultural research programs

Agricultural research should have as one of its basic purposes the formulation of technologies which can be widely used by farmers. Our purpose in this manual is to present procedures which will facilitate that effort, particularly in the planning stage.

Two themes are central to the Manual. The first is that effective research on agricultural technology starts and finishes with the farmer. The second is that integration of the perceptions of biological scientists and social scientists is an essential element in such research.

The Need for New Procedures

Although many farmers in developing countries are using improved varieties, few farmers are following in their entirety the recommendations made by researchers and extension workers. Why this occurs is the subject of a large body of literature. Some argue that farmers are at fault, some that extension is ineffective, others that credit is unsuitable, and some that inputs are not available in a timely way. A less frequently heard explanation is that the recommended technologies themselves are simply not appropriate to farmers.

Certainly one or the other of these explanations is valid at some time and place. But a number of recent experiences have shown even the poorest farmers—presumably the most traditionbound and usually those with least access to information, inputs, and markets—adopting certain technologies while rejecting others. Based on research on the diffusion of new cereals technologies 1/ in many countries, our own experiences and the reports of many others, we concluded that farmers do not adopt recommendations because they are not suitable for them. The adoption of new technology hinges on many interrelated factors. In general, farmers seek technologies that increase their incomes while keeping risks within reasonable bounds under their own circumstances, e.g. the resources available to the farmer, the climatic, soils and topographic characteristics of his land, the pest and disease complex of the crop, and the input and product markets in which he operates. We concluded that recommendations are often not consistent with these circumstances of farmers.

In conjunction with biological scientists in CIMMYT and national research programs, we began to search for concepts and procedures which would lead to technologies well adapted to farmers' needs. These procedures would have to integrate information on the many natural and economic circumstances that dominate farmer responses to alternative technologies. Moreover, to be useful to national research programs, these procedures should not require more research resources than are usually available.

The procedures themselves are guidelines for generating information about farmer circumstances which can then be used to orient research on improved technologies. We are convinced that such research can be made more effective if it proceeds from the current circumstances of farmers, hence the need to identify those circumstances. Those with differing views, e.g. those persuaded that researchers should only go to farmers' fields with finished technologies for demonstration, will find the Manual less useful than those who are supportive of on-farm research.

1/ See the series of CIMMYT adoption studies. A summary is given by R.K. Perrin and Donald Winkelmann in "Impediments to Technical Progress on Small Versus Large Farms," American Journal of Agricultural Economics, 58:5, 1976.

A Preview of the Manual

This Manual treats issues related to a single crop within the farmers' total cropping system. While the Manual features examples from maize and wheat (sometimes in crop mixtures), the procedures can be readily applied to other crops and cropping systems. Although we emphasize biological technologies the procedures also can be applied to the development of mechanical technologies.

We divide the Manual into three parts. Part I provides an overview of the concepts of a collaborative research process to deliver technologies appropriate to farmers and of the types of information regarding farmer circumstances that are needed for planning this research. Part II describes a set of procedures, with examples, for obtaining information from farmers at relatively low costs. Part III then provides procedures and examples for incorporating this information into the design of a research program. The management of on-farm experiments, the second dimension of on-farm research, is not treated here.

A Note to the User

The concepts and procedures presented here have evolved from our experiences with farmers and researchers in many countries. We fully expect that these guideines will be improved through the experience of other researchers. We hope users of the Manual will contribute impressions and examples from their own research for future editions. We authorize and encourage reproduction of any part of the Manual.

Donald L. Winkelmann
Director, Economics Program

PART I

the farmer as the primary client of agricultural research

In chapter 1 we present an overview of the organization of a research program that aims to develop technologies appropriate to farmers. We then note in chapter 2 the types of decisions that researchers must make in order to plan such a program and how a knowledge of farmers is critical to each type of research decision. Chapter 3 then discusses in more detail the type of information about farmers that will be important in research decision making. This then leads to Part II, which describes procedures for obtaining this information.

chapter 1 overview of research procedures to develop technologies for farmers

The procedures described in this Manual are part of a collaborative research process, based on the cooperation of applied scientists of different disciplines and farmers, to develop technologies which are appropriate to farmer circumstances and which help to meet the goals of national policy.

Now let us expand on the concepts contained in this statement. First, a *technology* [1/] is a combination of all the management *practices* for producing or storing a given crop or crop mixture. Each *practice* is defined by the timing, amount and type of various *technological components* such as seed-bed preparation, fertilizer use or weeding. A subsistence farmer who uses no purchased inputs is nevertheless using a technology —sometimes quite complex. We are particularly concerned with developing technologies appropriate to the *circumstances* of target groups of farmers. *Farmer circumstances* are all those factors which affect farmers' decisions with respect to a crop technology—their natural environment (such as rainfall), their economic environment (such as product markets) and their own goals, preferences and resource constraints. If technologies are *appropriate* to farmer circumstances they will, by definition, be rapidly adopted by farmers.

We also seek a technology that helps meet the *national policy goals* of government. Most governments desire increases in cereal production—therefore any technology which increases production and is rapidly adopted by farmers will help meet this goal. Most governments also have goals of reducing income inequalities. This may require technologies adapted to small farmers or to poorer regions or that provide cheap food to low-income urban consumers.

Applied scientists—that is, those scientists from different disciplines working to solve immediate and high priority problems—are, with farmers, the main participants in this research process. In most cases these scientists should include a biological scientist, usually an agronomist, to integrate the physical and biological aspects of crop production,

1/ A more appropriate term to describe the combination of practices used in producing a given crop is perhaps "technique." However, the use of the term "technology" has become so widespread in the literature of agricultural research that we have continued its use here.

and a social scientist, usually an agricultural economist, to integrate various aspects of the farmers' resource endowments, goals and market environment. These disciplines may be supplemented where there are specialized problems. For example,an entomologist might participate in solving a particular insect problem. An anthropologist might aid in understanding interactions between household members in decision-making for particular crop operations or interactions between households in the case in which a new technology might require cooperation of groups of farmers. We believe that it is essential that the agronomist and agricultural economist *collaborate* in all phases of the research and that major decisions such as the content of on-farm experiments are made jointly.

With these concepts as background, figure 1 gives an overview of an integrated research program for farmers. At the base of these procedures is on-farm research. This research, however, is linked to two other important factors in developing technologies. On the one side is experiment station research which emphasizes the development of new technological components such as new varieties. On the other side is agricultural policy which sets much of the economic environment such as national goals, input prices and supply, product markets and infrastructure in which researchers and farmers make decisions.

1.1 On-Farm Research

On-farm research is research conducted in farmers' fields with the participation of farmers. Effective communication of researchers and farmers ensures a greater awareness of the constraints and problems of farmers in the design of technologies. Experimentation in farmers' fields ensures that technologies are formulated under farmers' conditions and overcomes the difficulty of using experiment station results to make farmer recommendations, particularly where experiment stations are not representative of an area because of intensive management practices or location.

Because of its farmer orientation, on-farm research must explicitly identify the farmers for whom the research is intended. It is most efficiently implemented when focused on a particular group of farmers with similar problems and potentials.

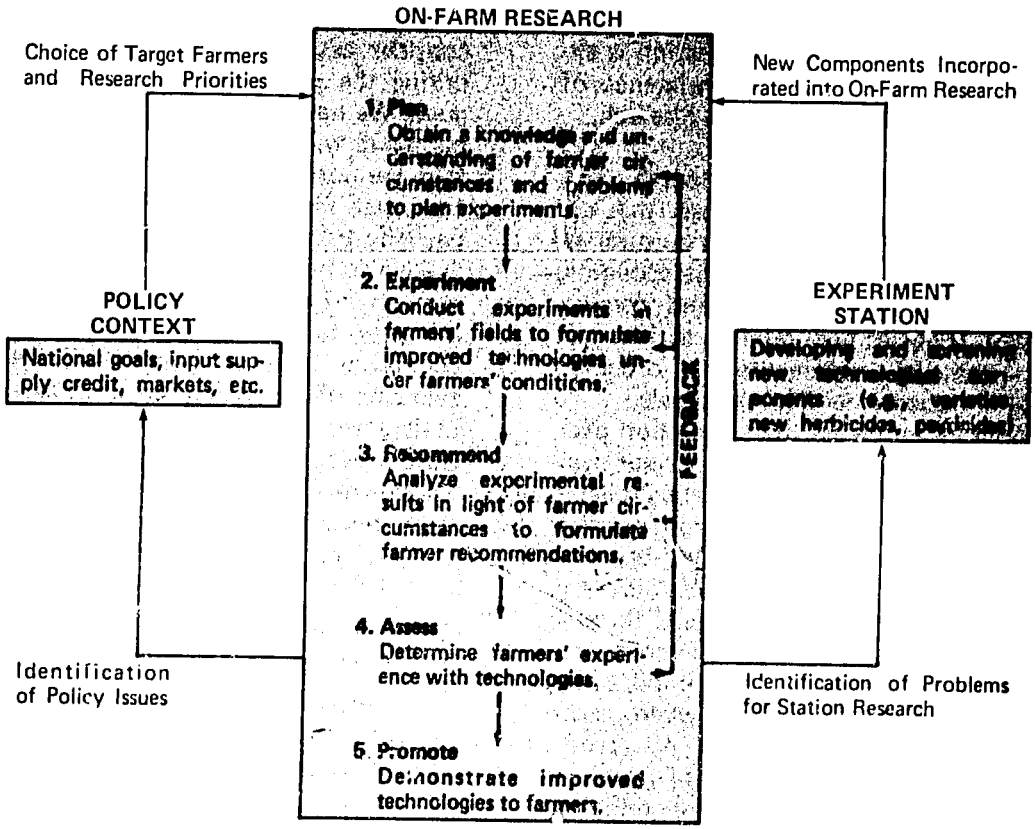
Various activities or stages of on-farm research are indicated in figure 1. In the planning stage, the research team, ideally including an agronomist and an economist, try to describe and understand farmer circumstances. This information is used to identify *priority* technological components which have the potential to increase production (or reduce costs) and which are consistent with the circumstances of target groups of farmers. Of course, it is often easy to identify many technological components, but the essential task at this stage is to identify priorities since research resources are limited and farmers, due to scarce capital and risk avoidance, usually have a limited capacity to absorb large changes in technologies at one time. At the same time agronomic experiments may be planted in farmers' fields to rank the production impacts of the various technological components. The priority components are then further investigated in the experimental stage in order to formulate improved technologies, that is, to construct, from *known* technological components and *known* biological relationships, technologies that improve upon farmers' existing practices. These experiments are conducted in farmers' fields so that technology is formulated under conditions similar to those in which farmers will use them. Technologies are then recommended to farmers after careful testing against farmers' technologies in several locations and after economic analysis of the results using procedures described in a previous CIMMYT manual, "From Agronomic Data to Farmer Recommendations."1/

The final phases of the on-farm research are to assess farmers' experiences with the recommendations and to promote the recommendations to farmers. Assessing farmers' reaction to the recommended technologies when they themselves pay the cost of inputs and bear the risks is an important feedback mechanism to the research process. If farmers are accepting the recommendations, researchers can turn to other problems while extension focuses on the task of further promotion of the technologies. If farmers are rejecting or substantially modifying the recommendations, then an understanding of why farmers do this might lead to a change of recommendations and even to changes in the experiments.

This on-farm research process is essentially dynamic as information is accumulated about farmer circumstances, the performance of various technologies in experiments and farmers' experiences with the technologies. Over time some

1/ See Perrin *et al, From Agronomic Data to Farmer Recommendations; An Economics Training Manual*, CIMMYT, 1976.

Figure 1. Overview of an Integrated Research Program



problems might be solved (or discarded because of a lack of solution) and new problems added. The system provides for continuing improvement in technologies as researchers apply information gained from past research cycles to plan future research.

1.2 Experiment Station Research

With a strong on-farm research program, research on experiment stations is primarily aimed at developing new technological components which require more controlled conditions, such as the development of new varieties. Also, experiment station research can be used to screen technological components that might have undesirable effects on farmers' fields, such as herbicides that might leave residues. Promising technological components arising out of experiment station research are further refined and evaluated in on-farm experiments for their appropriateness to farmers.

The flow of information between on-farm research and research stations is two-way. Information generated by on-farm research is important for guiding experiment station research. For example, information on farmer circumstances and from on-farm experiments may provide guidance on the type of variety that performs well under farmer conditions and that conforms to farmer preferences for maturity, yield, taste and storage quality.

Information from on-farm research aggregated over several regions can help establish broad priorities for the experiment station work. It can provide a valuable base for assessing the impact of alternative breeding decisions—for example, the relative emphasis that should be placed on earliness versus disease resistance. The information on farmer circumstances and from experiments helps establish the production benefit of each characteristic and the associated risks as well as the types of farmers that would benefit from each characteristic.

Increasingly we find that the information fed back to experiment station research is as important as the recommended technologies fed forward to farmers. This is because many experiment station research programs have lacked an effective mecha-

nism for relating research decisions to farmers' needs. In this situation, the on-farm research program should initially focus on screening the technologies developed on-station for relevance to farmers. This type of feedback information is extremely useful in determining the appropriateness of existing priorities in experiment station research.

1.3 Policy Context of Agricultural Research

Referring back to figure 1 we see that another important factor influencing agricultural research are the policies which shape the economic environment in which researchers and farmers make decisions. (Policies here refer to actions and rules of governments implemented in order to meet regional or national development goals.)

Many policies influence the production decisions of farmers. Some policies affect farmer decisions directly, such as the policy to make available only compound fertilizers and not single nutrient fertilizers. Most policies influence farmer behavior indirectly through their effects on input prices (e.g. through subsidies) or product prices (e.g. through marketing boards). These effects of policy on farmers' decision making in turn have implications for agricultural research. In countries where herbicides are expensive or difficult to obtain, researchers might orient research on weed control problems differently from that in a country where herbicides are cheap and available.

Policies may also influence research decisions directly. For example, many governments express the desire to make the distribution of real income more equal. This might influence the orientation of research programs toward poorer rural areas if most of the poor are in agriculture or toward regions with high production potential if most of the poor are in urban areas. In fact, most countries have many geographical regions needing assistance and insufficient research resources to initiate research programs in all regions. Measuring the characteristics of regions against national priorities such as increased production and income distribution is one factor affecting the choice of target farmers for a research program.

Agricultural research, and particularly on-farm research programs, can also provide valuable information to the policy maker that might encourage a change in policies to facilitate the introduction of improved technologies to farmers. For example, on-farm experiments may demonstrate the superiority of a given input which is not available to farmers because of import restrictions. Or information on farmer circumstances might identify important discrepancies between stated policy goals and policy implementation—for example, the late arrival of credit leading to untimely use of inputs.

Agricultural researchers must subjectively decide which elements of the policy environment to consider as fixed and which to consider variable during the planning horizon of the research program. We have just seen that researchers might experiment with technologies which require inputs that are not currently available under the assumption that they can demonstrate sufficiently high pay-offs from using the input to convince policy makers to make the input available. Other policies such as price policies might also vary as governments try to adjust to changing supply and demand conditions. However, there will be many other elements of the policy environment which reflect basic government strategy or which can only change slowly over time with increasing agricultural development expenditures (e.g. infrastructure) and these must generally be taken as given when researchers are making decisions.

1.4 The Place of this Manual in the Overall Research Procedures

This chapter has described a general set of research procedures in which farmers play a key role. This Manual focuses on the planning stage of on-farm research during which knowledge and understanding of farmer circumstances is obtained, farmers' problems are identified and potential technological components to solve these problems are narrowed to a few priority components for on-farm experiments. In this process, information that is useful to guide experiment station research and policy analysis is also obtained. This planning stage is part of an on-farm research program, which in turn is part of a broader program of agricultural research and policy analysis needed to improve production and incomes of farmers. We believe that this critical stage of explicitly considering the farmer as the primary client in agricultural research decisions provides an essential input into the organization and effectiveness of agricultural research programs.

The procedures developed here are an application of what has generally come to be known as "farming systems research." While we are primarily interested in developing technology for a target crop, the identification and evaluation of these technologies is done with the total farming system in mind. In areas where the target crop is a major crop in terms of farmers' resource use, this crop focus is a convenient means of focusing scarce research resources onto a manageable problem.

SELECTED FURTHER READINGS

CHAPTER 1

1. Dillon, John L. *et al*, "Farming Systems Research at the International Agricultural Research Centers," TAC/CGIAR, World Bank, Washington, 1978.
(Reviews procedures for farming systems research at various national and international research institutes.)

2. Hildebrand, Peter, "Generating Technology for Traditional Farmers: A Multidisciplinary Approach," Instituto de Ciencia y Tecnología Agrícolas, Guatemala, C.A., December, 1976.
(Describes methodology and implementation of an on-farm research approach in the Guatemalan Agricultural Research Institute.)

3. CIMMYT, "Summary Report Wheat Training On-Farm Activities, 1978" and "Maize Training: Report of Off-Station Experiments 1977 and Summary of Selected Experiments, 1973-1977."
(Contain results of experiments in farmers fields conducted by CIMMYT's wheat and maize training programs.)

4. CIMMYT, "The Puebla Project: Seven Years of Experience 1967-1973," El Batán, México, 1974.
(Describes a small farmer maize production project using technologies developed from on-farm experiments.)

5. CIMMYT Today No. 9, "CIMMYT Training," A. Wolff, 1978.
(Summarizes the philosophy and methods of on-farm experimentation in CIMMYT's in-service training programs.)

chapter 2 farmer circumstances as a basis for planning research

In the introduction to this Manual we said that successful research begins with the farmer—that is, planning research must explicitly take into account the circumstances of farmers for whom the technology is intended. In this chapter we define further what we mean by farmer circumstances and then show how information on farmer circumstances can be used in planning experiments.

2.1 Definition of Farmer Circumstances

Farmer circumstances in this Manual are defined as those factors that affect farmers' decisions with respect to the use of crop technologies (in our case for growing wheat or maize). Expressed this way, farmer circumstances explain both a farmer's current technology as well as his decisions about changes in that technology. Various farmer circumstances are shown in figure 2. They include natural and socio-economic circumstances. Socio-economic circumstances can be further divided into those that are internal to the farmer and over which he has some control (e.g. his goals and resources) and those which condition his external economic environment (e.g. markets).

Almost all farmers have a goal of increasing income, broadly defined to include production for home consumption. Generally too, small farmers have a security goal of meeting subsistence requirements of their preferred foods. They generally also want to avoid taking risks that might endanger their subsistence or cash sources of income.

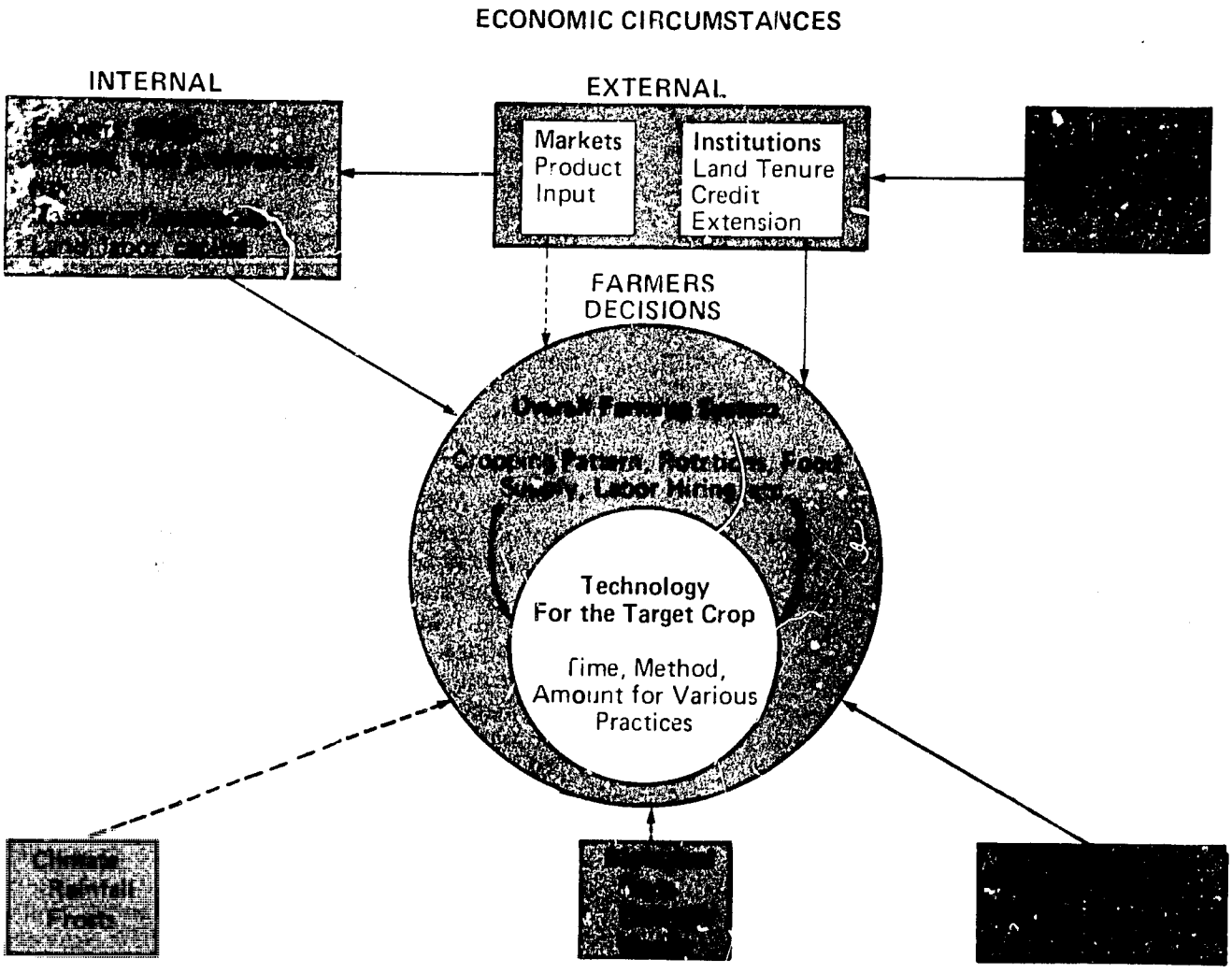
Farmers have relatively fixed quantities of resources of land, family labor and capital which they can allocate to meet these goals. (Capital resources here include both durable equipment and cash availability). Farmers may allocate these resources to different uses. Within limits they may also adjust the amount of a resource—for example, they may use some of the cash resources to hire more land or labor resources.

Many circumstances also define the economic environment in which farmers make decisions. These include the price and price variability for inputs and products, access to inputs and product markets, land tenure systems, credit facilities, physical infrastructure and so on. While this economic environment is largely outside of the control of a farmer, it is influenced by many policy decisions such as distribution of inputs, pricing policy and infrastructural development. A large number of natural circumstances also condition the farmer's decision making, such as soil slope and depth, climate, weeds and pests.

The farmer generally makes decisions accepting external natural and economic factors such as rainfall and prices as fixed, although he may be able to modify their effects. For example, a farmer may know that he has soils of different fertility and decide to plant crops which meet subsistence food preferences on his best soils to meet his goal of food security. Many external factors, particularly rainfall and prices, are variable and unknown to the farmer when he makes decisions. They provide an element of *risk* to farmer decision making. In figure 2 those factors which are major sources of uncertainty are marked with a dotted line. Risk may have important effects on farmers' decision making. For example, although a farmer may not be able to predict rainfall he is aware of the degree of variability and therefore takes actions such as planting a crop at several dates to avoid the risk of low rainfall at a particular period in a crop cycle.

Most of these factors have *direct* effects on farmers' decisions about a technology for a given crop. Late season frosts might cause farmers to seek an earlier variety to avoid risks. Expensive labor encourages farmers to use a less labor-intensive weeding method such as herbicides. Many factors affect the choice of a technology for the target crop because of *interactions in the farming system* (again refer to figure 2). The *farming system* is

Figure 2. Various Circumstances Affecting Farmers' Choice of a Crop Technology



---→Circumstances which are often major sources of uncertainty for decision-making.

here defined as the totality of production and consumption decisions of the farm-household, including the choice of crop, livestock and off-farm enterprises, and food consumed by the household. For example, a farmer may choose to plant maize late because he is planting beans early, in order to avoid disease problems in beans later in the season. Or he may plant an early variety of maize in order to have food early in the season before other crops mature. Examples of interactions in the farming system affecting the choice of a crop technology are many, and we will illustrate these interactions throughout the Manual. The point here is that crop technologies often result from decisions made for the farming system as a whole so that planning technologies for a specific crop requires knowledge of important interactions in the farming system which potentially influence that crop. We shall refer to these as *system interactions.*

The environment in which farmers make decisions is also subject to change over time. In particular, the external economic environment is characterized by changes in relative price ratios of inputs and products which affect farmers' decisions. Changes in the external economic environment may also directly affect farmers' goals and resources. As the market for subsistence food staples is developed, farmers are usually more willing to

depend on that market for food supplies and hence food preferences have less influence on production decisions. Likewise a new credit program may increase farmers' cash availability.

In the same way that farmer circumstances determine a current crop technology, they are also important in a farmers' decision to change his technology. Conflict of a change in a technology with any one of the circumstances of farmers may lead to rejection of that technology by the farmer. For example, varieties may be rejected because they are not suited to the soil conditions or because they mature too late for the planting of the next crop. Fertilizer recommendations which maximize yields may be rejected because these are not consistent with either the income-increasing or risk-avoiding objectives.

Clearly farmers reject available technologies not because they are conservative or ignorant, but because they rationally weigh the changes in incomes and risks associated with these given technologies under their natural and economic circumstances and decide that for them the technology does not pay. Our task then is to show how to incorporate a knowledge of farmer circumstances into the design of technologies so that they are consistent with farmer circumstances.

2.2 Decisions Required for Planning an On-Farm Experimental Program

Researchers must make a series of decisions in planning an on-farm experimental program. First, the researchers must determine if farmers in the region are sufficiently alike to allow a common set of experiments and a common recommendation. If there are significant differences among farmers, researchers must somehow divide farmers into more homogeneous groups and design experiments for each group. They must then decide what problems are going to be investigated and which technological components will be included in experiments for each group of farmers. For each technological component included in experimentation, the levels, timing and type of input or practice must be chosen. Then for each set of experiments, researchers must determine the levels of non-experimental variables or those variables which are fixed for all treatments in the experiments. Finally, the researchers must choose sites on which to locate the experiments. The circumstances of the farmers for whom the technology is intended will be a key factor in all of these decisions.

2.3 Grouping Farmers into Recommendation Domains

It is true that no two farmers have *identical* circumstances and therefore identical needs for technology. It is also true that a research program cannot be established to provide recommendations for each farmer. It is therefore necessary to classify farmers with *similar* circumstances into *recommendation domains*—groups of farmers for whom we can make more or less the same recommendations. At least a tentative delineation of these recommendation domains is necessary in planning on-farm experiments since the research priorities and consequent experiments might be different in each domain.

Clearly, the number of recommendation domains depends on the amount of variation in farmers' circumstances—the more variation the more domains needed—and on the amount of research resources—the more resources the more domains can be afforded. The final decision on the number of domains will be a trade-off between these two factors. However, it is well to remember that the researcher need not seek precise recommendations but general guidelines which the farmer can adjust to his own circumstances.

Recommendation domains can be defined on the basis of the various farmer circumstances. They may be determined by variations in the natural circumstances of the farmer such as rainfall, soils or diseases. A given region may contain many *agro-climatic environments.* These are areas where a crop exhibits roughly the same biological expression so that we would obtain, for example, similar varietal or fertilizer responses, *everything else being equal.* These agro-climatic environments are, however, often modified by socio-economic circumstances that produce different recommendation domains. For example, close to a large town maize may be grown largely for sale as fresh ears while further away it is a subsistence grain. Such differences may impose modifications on varietal selection and planting date. More commonly, even if all locations are in the same agro-climatic environment, the resource endowments of farmers may lead to different technological needs. For example, small farmers with scarce capital relative to labor and who place more emphasis on food security may follow quite different cropping patterns and practices from large farmers in the same agro-climatic environment.

At times a recommendation domain may result from a complex interaction of agro-climatic and socio-economic factors. For example, within an agro-climatic environment for maize there may

be different disease incidences for beans which cause farmers in one part of the agro-climatic environment to plant beans early, therefore delaying maize plantings. In this case recommendation domains may result from natural circumstances (i.e. diseases) affecting bean production and an economic circumstance (i.e. labor scarcity) translating this effect onto maize practices.

Recommendation domains are not necessarily continuous geographical areas. For example, two neighboring farmers may be in different recommendation domains because of large differences in available resources. Even within a farm there may be different recommendation domains due to variation in soil type or topography.

It is clear then that a knowledge of farmer circumstances and how they affect crop technologies will be a necessary element in defining these recommendation domains.

2.4 Identifying Farmers' Problems and Prescreening Technological Components for On-Farm Experiments

Farmers face many constraints which directly limit production and incomes, such as weeds, pests, diseases, inferior varieties and drought. Few research programs can investigate all of these problems, so priorities must be established to choose for research those few problems which are most important in limiting farmers' production and incomes and for which technological components exist that promise immediate solutions to these problems. For each important problem there may be several technological components available that contribute to its solution. For example, a weed problem might be reduced by changing rotations, time and method of land preparation and planting or seeding rate, or through improved manual weeding techniques or use of a herbicide. In planning experiments it is necessary to *prescreen* from these various components those few *"best-bet"* components which have a high probability of success. Since the final choice of components for on-farm experiments must be compatible with farmer circumstances, a knowledge of these circumstances is essential not only to identify problems but also to prescreen technological components. Information on farmer circumstances also helps define levels over which to experiment for the technological component. If fertilizer is expensive, rainfall is variable, and farmers have limited cash, the relevant range of levels for on-farm fertilizer trials will be lower than where each condition is more favorable for fertilizer use.

2.5 Establishing Representative Practices and Sites for On-Farm Experiments

One important reason for conducting experiments in farmers' fields is to be able to formulate technologies under farmers' conditions. Information on farmers' practices helps design experiments in which non-experimental variables reflect farmers' conditions. For example, in a research program emphasizing variety, fertilizer and weed control (i.e. the most limiting practices), non-experimental variables such as time and method of land preparation, planting method and pest control should be maintained at farmer levels to reflect the results of variety, fertilizer and weed control under farmers' conditions. If farmers interplant maize and beans while researchers do not, then weed control recommendations arising from research may not be appropriate for farmers, and in the absence of effective weed control the profitability of fertilizer recommendations can be markedly altered. Likewise it is important that sites for on-farm experiments are representative of most farmers in a recommendation domain with respect to soils, crop rotations, topography, location and farm size. If maize is grown on a particular soil type, then fertilizer experiments on maize should be planted on fields of this soil type. While it is easier to choose sites that avoid travel or are identified by cooperating extension personnel, these sites will often not be representative of farmers in the area.

With base practices at the levels of representative farmers, the researcher can be sure that farmers will obtain results similar to those obtained in the experiments. However, if new and profitable levels of the experimental components are not identified, then the researcher must make experimental variables of some of those components he thought were of lesser importance and which he had held at farmer levels. In one country, efforts to formulate appropriate new practices for wheat took the planting date as practiced by farmers. The effort was not notably successful until planting dates were moved well forward (quite feasible for those farmers); then new technologies emerged which were readily accepted by farmers.

2.6 Identifying Problems for Experiment Station Research and Policy

So far we have emphasized using a knowledge of farmer circumstances to guide on-farm experimentation. But as we showed in Chapter 1, on-farm research is closely linked to experiment station research and to policy decisions. The knowl-

edge of farmer circumstances obtained in on-farm research therefore plays another role in guiding these two activities.

One of the major activities conducted on experiment stations is the development of new varieties. Knowledge of farmer circumstances is important for identifying the priorities to be attached to various breeding objectives. Do farmers need earlier varieties to increase cropping intensity or reduce late season weather risks? Do they need varieties with specific insect or lodging resistance? Or do they need to improve storability because of difficulties in the marketing system? The answers to these questions depend on the circumstances of farmers for whom the variety is intended.

Sometimes this information on farmer circumstances will have to be quite detailed. In one country farmers regularly strip the lower leaves from their growing maize to feed animals. Researchers had demonstrated that leaf stripping reduced yields notably, hence had recommended against the practice. Furthermore, the researchers were working on new varieties of maize having a more streamlined plant, shorter and with fewer leaves but with less buffering to leaf stripping. However, experiments conducted using *farmers' time and method* of leaf stripping showed that, in fact, existing varieties with some redundancy and buffering, permitted leaf stripping with little effect on yields. With information on the value of leaves and the real yield loss when stripping is combined with the existing varieties, researchers now have a measure of the amount by which yields of grain must be increased if farmers are to adopt new varieties which do not tolerate stripping.

Information on farmer circumstances also helps identify policy problems which may impede successful introduction of new technologies. In one country decision makers believed that insecticides were easily available to all farmers. However, information obtained from farmers demonstrated that this was not the case at all; some insecticides were available in one place, some in another, and the distribution of insecticides did not at all coincide with the distribution of insects. This information demonstrated to administrators the need to re-examine the input distribution system. Often information from research will show policy makers the potential benefits from changing policies. For example, if fertilizer is in short supply, they may want to conduct some experiments to provide information to policy makers on fertilizer response. These become experiments for recommendations to policy makers, not for recommendations to farmers since farmers don't initially have access to the input.

chapter 3 a checklist of information on farmer circumstances

In this chapter we set out a "checklist" of information on farmer circumstances which is useful in planning experiments. We call it a checklist because it provides a systematic way of arraying the information we need and is therefore a reference for Part II of the Manual on procedures for obtaining this information. Only a part of this checklist of information will be relevant in any given situation.

The checklist of information is organized following the framework for analyzing farmers' circumstances that we developed in figure 2. Information is classified into natural circumstances, the external socio-economic circumstances of markets and institutions, the farmers' own goals and resource availability, the relevant features of the total farming system and a detailed description of the production practices for the target crop. The aim here is to be able to understand the farmers' production practices as a function of the particular natural and economic circumstances in which they operate. Finally, information is needed to diagnose those factors in the target crop limiting productivity in order to identify research priorities.

These relationships are illustrated in more detail in table 1, which shows the many potential effects of farmer circumstances on farmers' choice of a crop technology or farming system. On the left are listed various management practices for the target crop (in this case, maize) and the farming system. On top of the table are some of the various circumstances that we have discussed in Chapter 2. The food security goal is represented by the first two columns. The income goal and the fact that income can be increased by changing the productivity of the various fixed resources are shown in the next three columns. On the right are the various external natural and economic circumstances that create hazards or risks for farmers. Some farmer circumstances such as topography, soil type, land tenure, input distribution, etc. have been omitted from this table to keep it from becoming too large.

A variety of farmer circumstances may influence any one practice. Take the example of the number of plantings of the crop in one season, listed as practice No.9. It is checked against six potential circumstances: (A) preferred food staple, (B) food needs at specific times of the year, (D) labor scarcity, (E) rainfall uncertainty, (G) floods, (I) pests. Several plantings of a crop made over a period in the rainy season may be a practice influenced by several of these circumstances at the same time. For example, the staggered planting of maize will prolong the availability of green maize cobs for roasting—a favorite food in many communities (influence A). At the same time, a very early planting of an area of maize, before the main crop, can give an early harvest of new food at a time when stored supplies from last year's harvest may be running low (Influence B). Although a given time of planting may give the highest yield per hectare of maize, the labor available to the farmer may limit his ability to prepare seedbeds and establish maize at that time (Influence D). By staggering plantings of his maize crop over a two-month period he may be able to establish three times the area he could establish by planting at the technically optimum time, and the increased area may more than compensate for the decline in yields of the later planted crop. Furthermore, in areas where rainfall uncertainty is a dominant hazard, several plantings reduce the probability of losing the whole crop (Influence E). If a period of drought strikes when the first planting is at flowering (a period of very high water demand), losses from that planting will be heavy. Subsequent plantings, at earlier stages of maturity which have lower water requirements, will be less affected, so risk of losses from rain failure will have been reduced. Finally, floods, pest and disease attacks

Table 1. An Inventory of Potential Influences on Small Farmer Management Practices of Maize

FARMER CIRCUMSTANCE A–N / PRACTICES 1 – 25		Preferred food staple or relish	Food needs at specific time of year	Land scarcity	Labor scarcity	Capital scarcity or poor cash flow	Rainfall variability	Floods	Soil erosion and degradation	Pests	Diseases	Weeds	Poor retail distribution	Food and cash crop prices unstable	Seasonal variation in food prices
A. ON THE TARGET CROP		A	B	C	D	E	F	G	H	I	J	K	L	M	N
Choice of soil type	1		⊗	X	X		X	X	X		X				
Choice of location	2		⊗				X	X	X	X	X	X			
Methods of seedbed preparation	3				⊗	X	X		X			X			
Time of planting	4		⊗	X	⊗		X	X		X		X			X
Method of planting	5				X							X			
Spacing	6			X	X		X					X			
Plant population	7					X	X	X		X	X	X			
Variety used	8	⊗	⊗			X	X			⊗	X	X			
Number of plantings made	9	X	⊗		⊗		X	X		X					
Intercropping	10		X	X	⊗		X		X	X	X	X			
Relay cropping	11		X	X	X				X			X			
Frequency and timing of weeding	12				⊗	⊗			X	X	X	⊗			
Use of fertilizer	13			X		X	X		⊗			X	X		
Method and time of harvest	14	X	⊗	X	X					X	X				
Method of processing & storage	15		X			X				⊗					X
Use of herbicide	16				X	X						X	X		
Use of insecticides	17					X				X			X		
B. IN THE FARMING SYSTEM															
Growing preferred foods	18	⊗	X										⊗	X	X
Growing non-preferred foods	19		X	X	X		⊗			⊗	X		X		X
Crop rotation	20								⊗	X	X				
Renting of land	21			X											
Hire of labor and machines	22				X	X	X								
Labor reciprocity	23				X	X									
Winter land preparation	24				X	X	X		X	X	X				
Firing or bush fallow	25								⊗		X				

X Farmer circumstances potentially influencing choice of a management practice

⊗ Farmer circumstances governing choice of practices in one study area

may require replanting (Influences G, I). For any given group of farmers only some of these potential relationships will be important. For example, table 1 shows that for one study area (influences circled) the need for food at certain times and labor scarcity were major factors affecting the number of plantings made.

3.1 Natural Circumstances

Natural circumstances influence farmers' decisions by imposing particular biological constraints on the crop (e.g. the pattern of rainfall affects decisions on time of planting). Natural circumstances—particularly weather—also create an environment of uncertainty which risk-averting farmers must take into account.

Climate: Often the major climatic factor affecting farmers' decisions is rainfall. The average amount and within-year distribution of rainfall indicates the potential for the crop in question, the length of the growing season and the potential planting dates. Year to year variability in rainfall indicates the level of risk faced by farmers and the months when this risk might present special management problems. In some cases too much rain may be the critical problem during some months or some years. Other climatic variables are also potentially important. Early or late frosts may be the limiting factor on the growing season and a major risk to farmers. Often a combination of climatic factors may be critical. For example, late planting when rains are more sure may increase the risk of frost later in the season.

Soils and Topography: Differences in soil and topography affect farmers' management practices. Varied topography or soil within a farm are usually exploited by farmers. Valley bottoms will often support a longer growing season but may become waterlogged at the height of the rainy season. Alternatively hillsides may be less suitable in drier seasons or may create particular problems of erosion management. Opportunities for mechanization of land preparation or weeding are affected by soil texture and topography.

Pests and Diseases. The incidence of insects and diseases will often be associated with climatic variables (e.g., humidity in the case of wheat rusts). As with climate, the variation in pest and disease incidence across years may be important in understanding risks faced by farmers. Management practices of farmers often relate to pest or disease problems. Farmers may follow particular rotations to reduce the incidence of these problems or may time their planting of the crop so that climatic conditions are not so favorable to the disease/pest. Problems with storage pests might also lead to particular practices such as selling immediately after harvest or planting early to obtain an early source of food supply.

3.2 External Socio-Economic Circumstances

Many socio-economic circumstances affect the external environment in which farmers make decisions. Here we consider those external circumstances over which individual farmers have little control.

Community Organization and Structure: Some knowledge of the functioning of local village leadership and organizations is often useful in understanding current patterns of resource distribution as well as for identifying farmers with whom to work with on-farm experiments and demonstrations.

Physical Infrastructure: The condition of local roads and transport, particularly in the wet season, often has an important bearing on farmers' participation in input and product markets.

Product Markets: It is important to understand the market faced by the farmer, both in the sale of his crop and the purchase of food staples. This will affect farmers' storage and selling strategies as well as risks associated with cash incomes versus subsistence production. Factors to consider here are the major marketing channels for the crop in question, the seasonal and annual variations in price levels over recent years, the spread between the producer and consumer prices, government price guarantees and the availability of milling facilities for processing subsistence consumption.

Labor and Machinery Market: Information is needed on the local labor market, such as the available farm labor force from local sources (e.g. landless workers), competing labor opportunities (e.g. industrial jobs) and important streams of seasonal migration into or out of the area. In many areas labor resources can be supplemented by hiring machinery, depending on the availability and cost of machinery services. The availability of hired labor and outside job opportunities will help identify farmer labor constraints and alternative employment opportunities, which in turn will have a bearing on practices such as planting and weeding where timing and amount of labor are often critical.

Input Markets: Information on the various distribution channels for farm inputs, on prices, price trends and availability of key inputs is important in understanding farmers' use of inputs and in designing technologies that depend on purchased inputs.

Land Tenure and Settlement Patterns: Land tenure often influences production practices. Landlord/tenant systems may lead to disincentives to intensive management if the rental is paid as a share of the harvest. Soil conservation practices may require some long-term security of use. Fragmented holdings often result in fields of different soil type and topographies leading to more complex management patterns. For example, particular crops that require more intensive management or that play an important role in the local diet are often located in fields closer to the village.

Credit: Knowledge of credit availability and its cost, whether from formal sources (banks) or informal sources (money lenders), is important for analyzing farmer purchases of cash inputs, use of hired labor and the selling/storage strategy of the crop. Many times there are additional costs of credit which increase the cost of capital. These include service fees or delays in input delivery associated with bank credit or lower product prices received by farmers from money lenders who oblige customers to sell their produce through them.

Extension: It is valuable to examine the recommendations promoted by the extension service; first to assess farmers' knowledge of those recommendations, and then to assess among knowledgeable farmers which pieces of the recommendations have been adopted and which nave been rejected by local farmers and why. This helps understand some of the important circumstances influencing farmers use of new technologies.

Changes in Socio-Economic Circumstances: The evolution of the farming system over time is primarily determined by changes in the external socio-economic circumstances in which the farmer operates. For this reason it is useful to examine trends in prices received and paid by farmers and how these are reflected in trends in the enterprise combination and management practices employed by farmers. Changes in resource use, ownership, and land tenure patterns also often help in understanding critical underlying trends in the system.

The Policy Environment: The external socio-economic circumstances of farmers are strongly influenced by policies and their implementation. It is therefore useful to try to understand how key elements of the external socio-economic environment such as prices and input distribution are being influenced by government policies. Moreover, it is important to distinguish between those influences that conform to the stated goals of government policy and those that relate to problems in policy implementation so that actual results of a particular policy are quite different to the stated policy goals.

3.3 Resource Constraints

Land: Land resources available to farmers influence such practices as type of crop rotation (e.g. length of fallow), soil management practices (e.g. use of organic manures) and use of machinery. Over time in most rural areas increasing population leads to greater pressure on available land resources. Measures of land scarcity are the intensity of land cropped in a given year and trends in price or rental value of land in the area. In areas where land is becoming very scarce, research may be needed on fertility, water management, crop rotations and multiple cropping.

It is important to know the system of rotation followed including the amount and length of fallow (in either shifting or permanent cultivation) and sequences of rotations of specific crops in the farming system. It is often useful to relate variations in these patterns to differing population pressures, pest-disease incidence, topography or soil type.

Cash: For most small farmers cash is a constraint on using new inputs (at least at some period of the year); farmers' actions often reflect cash constraints. Cash constraints may be reflected in practices such as selling home-produced food soon after harvest at low prices and then repurchasing food at higher prices at a later date. Farmers who work off-farm at periods when there is a labor shortage on their own farms or take loans in the informal credit market at certain times of the year on relatively unfavorable terms also are likely to be reacting to cash constraints. Identifying behavior such as the above can help to establish both the magnitude and timing of cash constraints.

The nature and timing of the cash constraint is best seen through a calendar of cash flows that indicates seasonal inflows due to farm sales and other sources of cash income (e.g. off-farm employment) and seasonal outflows, such as input purchases and other necessary expenditures— such as food purchases and school fees.

Family Labor: Family labor is one of the major inputs for small farmers. Seasonal shortages of labor may have major impacts on farmers' practices. This can be gauged by determining first, the busiest periods of the year and the type of work done during these periods, and second, those periods and type of work for which farmers hire labor. This alerts us to look for practices such as staggered plantings or problems such as weeds, related to labor shortages.

Capital: Farmers' stock of capital consists of their equipment and animals used for farm work. An inventory of major capital items owned by the farmer and used in the production of the target crop is important since farmers who own these items might be quite different in both the intensity and timing of practices in which these capital items are employed to those farmers who have to depend on rented equipment. Moreover, to understand farmer practices it may be necessary to consider particular maintenance problems of capital items such as problems in keeping working animals in good condition in the dry season in order to plough immediately after the rains begin or problems in maintaining a tractor in running order during the busy season.

3.4 Farmers' Goals

A primary goal of farmers is to increase income. This is achieved through increased productivity of the resources—land, labor and capital—discussed above. Farmers' income goals are however modified by food preferences and risk aversion.

Food Consumption and Preferences: If the crop of interest is an important part of home consumption, it may be necessary to know something about seasonal food supplies and food processing and consumption patterns and preferences. These may influence farmers' cropping patterns, choice of variety, planting dates and storage and marketing strategies. Farmers often grow security crops to act as substitutes for the preferred foods. There are often differences among varieties with respect to suitability for local processing methods

and local tastes. If food has to be purchased, then the cash requirements might lead to other practices and problems, such as untimely or inadequate weeding due to insufficient cash to hire labor.

Risks and Risk Management: In most areas, an understanding of farmer practices requires an understanding of the overall risk situation of the farmer and what management strategies can be used in the face of those risks. Uncertainty arises from both the natural and economic circumstances of farmers.

For the major crops in the system, we need to know the frequency and causes of crop failure and the severity of each in terms of food and cash needs. It is also necessary to know the specific nature of the problem. If the failure is due to rainfall, we need to know if the problem is caused by a late start to the rains, early finish or a mid-season dry period. If it is due to a pest or disease, we need to know the timing of the problem and the conditions under which it is most prevalent. For each problem farmers may follow *insurance* practices to *reduce* the risk. For example, farmers may stagger planting to reduce the effect of rainfall unreliability. They may follow particular rotations to conserve moisture or reduce pest problems. Finally farmers may take *specific* measures when the problem occurs (e.g., spraying for an insect problem or replanting with a short season crop when early rains fail.)

Uncertainty in product markets also affects management practices. Variability in prices may lead to insurance strategies such as crop diversification or storage.

3.5 Farming System Interactions

Many of the influences of farmer circumstances on management practices in the target crop are direct influences (e.g., rainfall affecting time of planting) but many are influences operating through interactions in the farming system. These interactions are often overlooked.

Some farming system interactions are direct interactions between enterprises where products of one enterprise are used in the production of another enterprise. The most common example of this type of interaction is between livestock and crop enterprises. For example, farmers often plant maize at high density to provide thinning for animals or plant a maize variety with sufficient vegetative growth to allow leaf stripping. It is also a common practice for farmers in dryland wheat-producing areas to leave weedy fallow for livestock feed; this has adverse effects on moisture availability for the following wheat crop. If animals are also used for land preparation, then availability of forage often affects the availability and strength of traction animals, with important consequence for method and timing of land preparation.

Many farming system interactions also occur through competition for scarce resources. In areas where more than one crop is planted per year, crops often compete over time for the same land. Crops may be planted after the optimum time to obtain highest yields because farmers have to wait for the preceding crop to mature. In many areas enterprises compete at certain times of the year for scarce labor and/or cash resources (since cash resources can be used to hire labor). In such cases farmers often reject such labor intensive practices as thinning or delay such operations as weeding beyond a time that would maximize yields.

Finally farming system interactions occur through efforts of farmers to manage available resources to meet goals of supplies of preferred foods and risk avoidance. Managing food supplies may result in practices such as early planting or use of an early variety to provide an early source of food. Risk avoidance is expressed through crop diversification and planting of crops which are less risky although perhaps less preferred as foods and/or less profitable.

The importance of some of these interactions in explaining farmers' practices for a given crop means we may require detailed information on the farming system. For example, if crop-livestock interactions are important, we may need to gather information on the livestock sector to learn about seasonal forage sources and markets for forages. Or if labor is a constraint at a given period, we may need to focus on operations in other crops at that time in order to understand why these operations are performed when they are. We may also need to investigate the supply of hired labor and seasonal migration.

An understanding of the effect of these interactions on current practices will, of course, also be important in prescreening new technological components. It might mean that we have to evaluate carefully the effects of new components on forage availability or labor requirements at certain periods of the year.

The type of information needed on other parts of the farming system will depend on the particular system interactions influencing management of the target crop. It is not possible here to provide a checklist to explore all of these interactions. As a general rule, however, it is useful to establish a calendar of activities for the farming sys-

Table 2. A Checklist of Information on Crop Management Practices

Land Preparation [illegible] Equipment used in each operation Variation in method with seasonal conditions	**Fertilizer** [illegible] Timing of each in relation to planting, weeding, harvest, etc.)
Planting Variety(ies) used Density and spacing Density and spacing of interplanted crops Time of planting in relation to rains, frosts, etc. Spread of planting dates Sequence of interplanting crops Method of planting (hills, broadcast, etc.) Method of covering seed Practices of replanting part or whole field	**Pest Control** [illegible] Timing of control **Irrigation** Method of irrigation Frequency and timing of each [illegible] **Harvest** Timing of harvest in relation to maturity Method of harvesting Use of [illegible] Taking [illegible] harvesting [illegible] Use of [illegible]
Thinning Method and timing Target density Use of thinnings	**Post Harvest** [illegible] [illegible] [illegible] Disposition of [illegible] Use of [illegible]
Weeding Number of weedings Timing of each in relation to planting Equipment used in weeding Use of herbicides (type, rate, timing and method of application) Use of weed [illegible]	**Seed Selection** [illegible] [illegible] [illegible] [illegible]

tem as a whole; that is, dates of planting, weeding and harvesting for various crops, the sequence of crops in an annual cropping pattern and the uses of the produce of each crop and livestock enterprise.

3.6 Description of Farmers' Technology for the Target Crop.

Clearly, an important class of information is the description of the management practices for the target crop. Table 2 provides a checklist of the various management practices. It follows the sequence of operations for producing the crop—land preparation, planting, thinning, weeding, fertilization—through to post-harvest operations and seed selection for the next crop. Not all operations are relevant in a given situation (e.g., irrigation in a rainfed production area). Note also that many practices require very specific information, both in the timing and sequence of operations. The example of leaf stripping in the previous chapter showed the need to be quite precise about the farmers' method of leaf stripping. In another case, the timing of irrigation in relation to the type of nitrogen fertilizer and application methods was important in understanding fertilizer efficiency problems.

Finally, information on how management practices are changing over time is useful in understanding key factors influencing farmers' decision making.

3.7 Identification of Limiting Factors

In order to choose technological components which will be adopted by farmers, we must be able to diagnose the constraints on farmers' production and income. We shall call these *limiting factors* or *problems.* A major set of these factors will be those that limit yield—that is, those agronomic factors such as a) variety, b) fertility and other soil—related problems such as salinity, c) weeds, d) diseases and insects, e) stand establishment or density, f) moisture, etc. Here we are only referring to immediate causes of yield losses. Of

course each of these problems might be a manifestation of more general problems. For example, disease is often due to a susceptible variety and weeds to scarcity of labor at the time of weeding. These factors are explored in relating farmers' practices to their circumstances.

Increased production and income might also be possible through more intensive cropping. For example, an earlier variety of maize might enable another crop (not necessarily maize) to be planted in the same season. Finally, there may be other ways in which farmers' income might be increased. These include reduced storage losses (since most small farmers store considerable portions of grain for home consumption) and improved grain quality (either for home consumption or for sale). Income might also increase by reducing the cost of an operation such as weed control.

In order to rank research priorities, it will be necessary to assess the extent of the loss associated with each limiting factor or constraint. We will also need to assess the incidence of these losses. Some factors may be relatively constant from year to year (e.g., weeds or the potential for increased cropping intensity) while others may lead to large losses in occasional years (e.g., diseases or drought). These latter losses have an additional cost since they increase farmers' risks. Finally, in order to propose technological solutions to a particular limiting factor we also must have specific details of the problem (e.g., type of weeds, type of pests or specific nutrient deficiencies).

SELECTED FURTHER READINGS

CHAPTER 3

1. Cleave, John H., "Decision-Making on the African Farm." In *Contributed Papers Read at the 16th International Conference of Agricultural Economists.* Oxford Agricultural Economics Institute, 1979. (A good review of the many factors or circumstances influencing farmers' decision-making.)

2. Collinson, M. P., "Demonstration of an Interdisciplinary Approach to Planning Adaptive Agricultural Research Programs: Serenje District, Zambia," CIMMYT East Africa Report No. 3, Nairobi. (Traces the many influences on farmers' management practices on maize in one study area of Zambia.)

PART II
procedures for obtaining information on farmer circumstances

In Part I, we have stressed the vital importance of understanding farmer circumstances in planning effective agricultural research. We now ask the question: how can we obtain this information cheaply and efficiently? Part II describes a set of procedures that we have found useful in obtaining this information. These procedures are not intended to serve as a recipe since a recipe presumes a given situation. Rather we want to provide a set of guidelines and principles to help researchers make decisions for their specific situations.

chapter 4 overview of the procedures

4.1 Sources of Information on Farmer Circumstances

Information on farmer circumstances can be obtained in several ways. First, there are secondary sources such as published census data or unpublished rainfall data. Second, there is information obtained by interviewing farmers and others with knowledge of farmer circumstances. These interviews may be conducted relatively informally through, for example, conversations between researchers and farmers, or more formally by interviewers using a written questionnaire. Third, information can be obtained by direct observations by researchers in farmers' fields.

Secondary sources of information should be used when they are available and reliable. However, rarely will there be adequate data already available about farmer circumstances—their farming systems, resource use, problems and constraints—for planning experiments. A large part of an information-gathering effort will have to be devoted to obtaining this information directly from the farmer and his fields.

Informal interviews with farmers and other persons knowledgeable about farmer circumstances are particularly valuable when conducted by the researchers themselves. These discussions place the researchers in direct contact with the farmer. Because researchers are free to structure the interview depending on the responses of the farmer, it is a very efficient procedure for obtaining a tentative understanding of the farming system, cropping practices and identifying production constraints. Also the informal setting of the interview often makes it easier to obtain sensitive or complicated information.

The formal interview, conducted with a questionnaire, has the advantage of providing a standard set of information from each farmer. Because a fixed questionnaire is used, well-trained interviewers may be employed, thereby making it possible to obtain information from a relatively large number of farmers (e.g., 50 farmers in a recommendation domain). Furthermore, farmers can be chosen randomly to provide a representative sample of farmers. In this way the researcher obtains a more

Figure 3. An Overview of Steps in Obtaining Information on Farmer Circumstances

STEP	SOURCE OF INFORMATION	SCOPE OF INFORMATION
[illegible]	[illegible]	[illegible]
3. Formal Survey	[illegible]	[illegible]

reliable picture of farmer circumstances in the area and can quantitatively communicate these results to others. For example, the researcher may be able to report to plant breeders that a certain percentage of farmers report a particular leaf disease or to policy makers responsible for fertilizer distribution that a certain percentage of farmers received fertilizer late.

Finally, direct field observation by experienced agronomists is valuable in identifying agronomic factors limiting production in farmers' fields. However, direct observation will rarely be sufficient for this purpose because observed problems will be specific to the stage in the crop growth cycle and the seasonal conditions in which the observations are made.

4.2 A Sequence of Steps

Figure 3 illustrates a sequence of steps which employs the various methods of obtaining information on farmer circumstances and which enables this information to be obtained relatively cheaply. First, researchers *assemble and analyze background data from secondary sources* and note those factors which will guide questioning of farmers (e.g., months of low rainfall suggest high risks to farmers or areas without roads suggest serious product marketing problems). The assembly of background information is followed by an informal *exploratory survey* in which an interdisciplinary team of researchers work together as a team. They traverse the region to observe farmers' fields and informally interview farmers and others, such as merchants or extension agents, familiar with farming in the area. No questionnaire is used, but the interviews are more than a casual conversation since the researchers have a systematic checklist of information to be obtained and hypotheses to be tested in the interviews. The exploratory survey is used to give researchers firsthand knowledge of farmer circumstances and their problems; to form hypotheses on reasons for farmer practices; and to tentatively identify technological solutions appropriate to these problems and circumstances. The exploratory survey also provides a base for organizing a *formal survey* to verify and quantify the information obtained in the exploratory survey. The formal survey uses trained interviewers to administer a questionnaire to a randomly chosen group of farmers. We emphasize that this formal survey should be conducted only after a thorough exploratory survey. The exploratory survey is necessary to decide what is the *important* information that should be collected in the formal survey, how the questions should be asked and how to choose a representative sample of farmers. (See Chapter 6).

There are many types of formal surveys ranging from statistical surveys involving quick visits to a large number of farmers to in-depth studies of a small number of farmers through recurrent visits. For the purposes of planning agricultural research, a single interview, sometimes supplemented by field observations, with a relatively small number of farmers is usually sufficient. Furthermore, the questions will focus on farmer opinions and details of management practices and will be quite different from many standard surveys for cost of production and agricultural statistics.

This information-gathering process is focused on information relevant to the content of on-farm experimentation. As shown in figure 3, the initial information obtained in the assembly of

background information and the exploratory survey is broad, covering the whole farming system and the natural and economic environments in which farmers make decisions. As the exploratory survey proceeds, the scope of the information being sought narrows, focusing more on management of the target crop and those aspects of the farming system and its environment which are most important in influencing the management of that crop. This information is verified in the formal survey.

The information from all these various sources must then be assembled in a form suitable for planning experiments. Critical factors limiting production are listed, possible technological solutions are identified, farmers' production practices to be used as a base for the experiments are noted and policy-related problems are identified.

4.3 Defining the Target Region

Since research resources are usually limited, a decision must be made regarding the definition of the area and farmers which are to be the focus of the research program. This is best done by an initial rough stratification of the country (or a province or state) into target regions which are roughly homogeneous with respect to agro-climatic characteristics and farmer circumstances. The decision to focus research on one of these regions will be dependent on a number of factors, including the importance of the target crop in the region, the apparent potential for increasing productivity of the target crop, and other agricultural policy objectives, such as the desire to improve the incomes of poorer farmers. In the initial stages of implementation of these procedures it is usually wise to select regions where human resources and logistics will not be major bottlenecks to implementation. With time, as researchers gain experience in implementation, logistically more difficult regions can be included in the program.

4.4 Implementing the Research Procedures

The process of obtaining information on farmer circumstances should be part of an ongoing process to plan and execute on-farm experiments. The same research team—the agronomist and the economist—will then be responsible for carrying out each of these activities over time in one target region. The team should be available *full-time* for this program of surveys and experiments. At times it will be necessary for the research team to include, at least on a part-time basis, researchers from other specialities depending on the type of problems identified. For example, if insects are a particular problem, an entomologist might participate in the field work and research planning. The contribution of an agricultural engineer would be valuable where there are special problems of water or machinery management.

The researchers will also need assistants for the survey and experimentation work. There are benefits from using the same assistants in both phases of the work. These assistants need not have high levels of education; rather, their practical knowledge of agriculture and their ability to work in the field and communicate with farmers are more important attributes. Chapter 9 describes in more detail some desirable characteristics of assistants. Finally, the research staff will require ready access to transportation since the success of the program depends on frequent field visits by the researchers throughout a region.

A desirable sequence of operations for an on-farm research program is shown in figure 4. In an ideal situation, the exploratory survey is conducted during the crop cycle in order to make important field observations of the target crop. For both maize and wheat the period around flowering is often a good time to observe agronomic problems in farmers' fields.

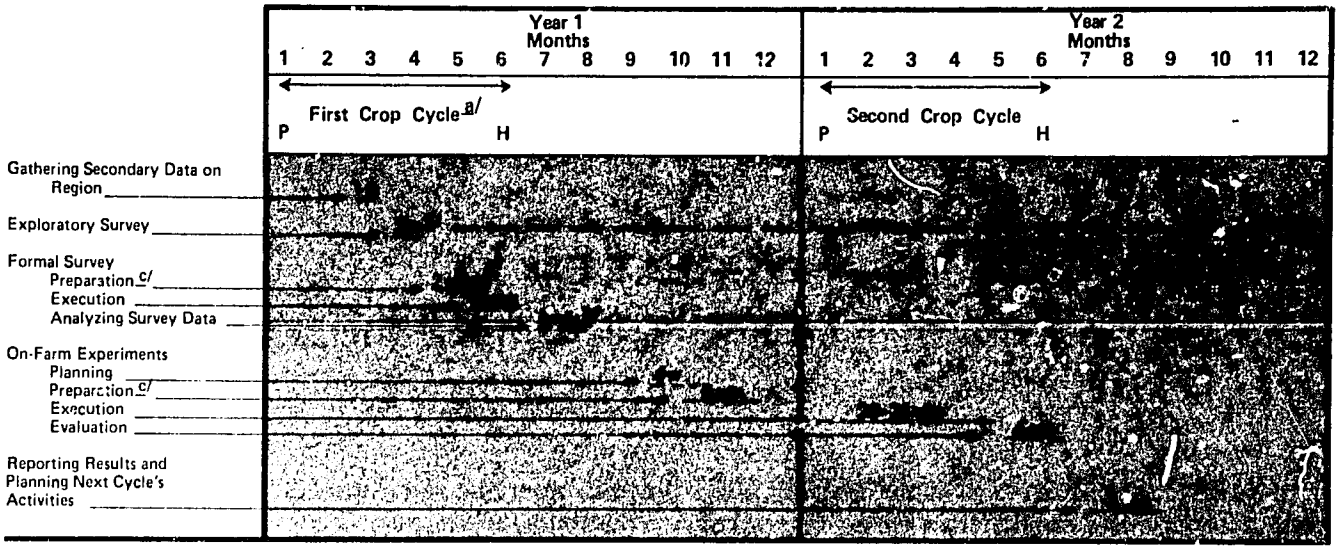
The period after the exploratory survey is used to design the questionnaire, train enumerators and prepare for the formal survey. However, the informal dialogue between researchers and farmers continues in a less intensive way throughout the research program. The formal survey is executed in the period immediately before or just after harvest; a time when farmers will have fresh in their minds the information for that crop cycle, and also a time in most agricultural areas when farmers are less busy. The data from the formal survey are then analyzed to develop an experimentation program for the following cycle.

We have found that the total sequence of procedures to gather information on farmer circumstances and plan experiments can be effectively implemented in one area in a period of three months —that is, one week for assembly and analysis of background information, two weeks for the exploratory survey, four weeks for the design and implementation of the formal survey and four weeks for data analysis and interpretation.

4.5 Adjusting the Procedures to Fit the Researchers' Circumstances

Just as technologies should be designed to fit different circumstances of farmers, so must the procedures used to obtain information from farmers be specific to the circumstances of each team of

Figure 4. A Suggested Time Table for an On-farm Research Program of Surveys and Experiments



a/ P=Planting; H=Harvesting

b/ Dotted lines indicate that these activities may be less than full time for the period.

c/ Preparation activities include sampling of farmers', design of questionnaires, training, etc. for the formal survey and site selection, assembly of materials etc. for experimentation.

researchers, e.g., the resources available for the research and the types of problems to be investigated.

The process described above is suggested as a model to be followed when a new on-farm research program is being planned. In practice, many variations in the sequence of steps have been tried. For example, the crop cycle in which the surveys are conducted can be used to obtain some preliminary experimental information. In this case, experiments based on available information are conducted at the same time as data on farmer circumstances are collected. Information from both the experiments and the surveys are pooled to plan research for the next cycle. In another situation, with few resources and little time, researchers may decide to focus on exploratory surveys in a few regions in order to tentatively plan on-farm experimental programs for these regions, and then later conduct some short, well-focused formal surveys at the same time as the first round of experiments. In yet another situation with limited time, both the exploratory survey and formal survey can be conducted in the dry season to provide information for planning experiments in the following crop cycle.

chapter 5 assembling background information

As one of the first steps in the research process, secondary data on the target region are assembled from diverse sources and analyzed. This provides useful background on the region for beginning an exploratory survey.

5.1 Sources of Secondary Information

Secondary information can be obtained from government sources such as maps, regular and *ad hoc* reports, and from other sources such as reports of a research organization. Since many of these sources will only be available in the national or regional capital, the process of assembling secondary data may involve travel to these centers.

Here are some examples of these types of reports:

Agro-Climatic Data: Monthly rainfall and temperature data are usually available from individual weather stations or from the national weather service.

Topographic Data: Topographic maps of a scale of about 1:50,000 are available from cartographic units in nearly every country. They are extremely valuable in defining the area and in sampling and conducting field operations.

Soils Data: Soil maps are often available from soil survey units and help define the variation in soil types affecting cropping patterns as well as drainage and fertility problems. Available soil analyses also can help in decisions on fertilizer experiments– particularly in the case of phosphorus and potassium.

Population Data: The latest population census can provide data for local government units or villages. When urban areas are excluded, these data provide a measure of population density and the variation in land pressure in the area. This can alert the researchers to possible problems of declining soil fertility or erosion.

Production Data: Agricultural census data provide information on area and yields for major crops grown in each local government unit. Variation in cropping patterns and yields across the region can help to guide later questioning in the field.

Price and Market Data: Information on the quantity, prices and distribution of inputs, production and credit often can be obtained from reports of public and private agencies operating in the region such as banks, seed production agencies and marketing boards. Time-series data on product prices might alert us to changes in cropping patterns. Seasonal price data might indicate particular storage or risk problems for farmers.

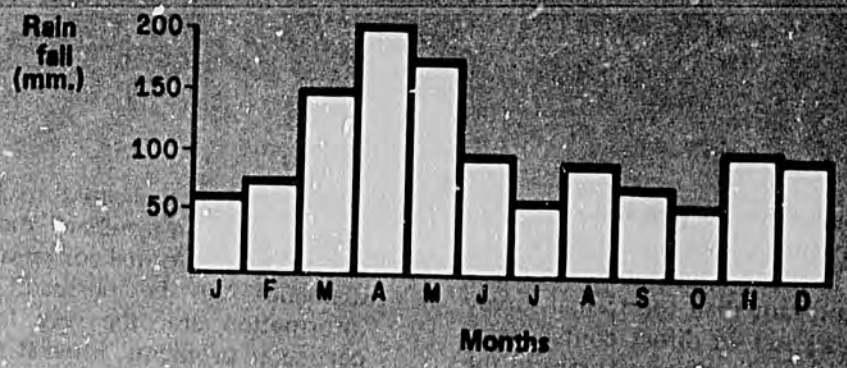
Research Data: Reports of previous research conducted in the region are particularly valuable since they usually contain more detail and better quality data than official censuses. Data from farm-level surveys and previous on-farm experiments will often be relevant to the task of planning future research.

5.2 Analyzing Secondary Information

All secondary information should be analyzed for variations across the region. At this stage it should be possible to check hypotheses about recommendation domains. If climatic data show sharp variation in rainfall across the region, we might check the production statistics to determine if this variation in rainfall results in different cropping patterns or yields. Data on factors which cause uncertainty in farmer decision-making such as rainfall and prices should also be analyzed for year-to-year variation.

Example 5.1: Average Monthly Rainfall Profile

A histogram of monthly average rainfall shown below indicates that rainfall is low at this site in January. At this location, researchers subjectively estimated that, given local soil and temperature conditions, maize would need at least 75 mm of rain in January to support a January planting. Examination of historical rainfall data showed that this only occurred in 10 out of 26 years (i.e. fewer years [illegible] planting is quite risky. [illegible] possible to reduce this risk [illegible] an early variety or [illegible] followed by early maize. [illegible] analysis of rainfall [illegible] lookout for [illegible] farmers.



Example 5.2: Analysis of Secondary Data for Drought and Frost Risk for Highland Maize

In a highland maize-producing area where some supplemental irrigation was available, rainfall data and data on frost incidence were particularly valuable in establishing the degree of risk faced by farmers. The table below shows that maize planted in September has the lowest frost risk but also has a considerable drought risk at the time of planting. In this case, the data indicated that farmers with supplemental irrigation to enable September planting and avoid both rainfall and frost risks would likely use quite different practices than farmers without irrigation who were more exposed to the risks of drought and frost.

Month	Probability of Less Than 30 mm Rainfall in Month 1/	Probability of 2°C Frost Exposure if Planted in Month 2/
	Per cent	Per cent
August	90	27
September	30	13
October	10	25
November	0	39

1/ Rainfall below 30 mm was estimated to be insufficient to [illegible]

2/ Probability of frost from the first month after planting to one month [illegible]

chapter 6 the exploratory survey

6.1 The Role of the Exploratory Survey

The exploratory survey is essential in obtaining information about farmer circumstances. In many ways it is more important than the formal survey since it places researchers in direct contact with farmers and enables them to observe firsthand the farmers' crop and cultural practices.

The essential objective of the exploratory survey is to quickly gather information through informal interviews with many people—and particularly farmers—in order to arrive at a tentative description of farmer practices as well as an understanding of why, in light of their particular circumstances farmers follow those practices. This information is useful in refining recommendation domains and identifying potentially improved technologies to overcome major factors limiting production and incomes.

The exploratory survey is also used to help design a well-focused formal survey to verify and quantify information obtained in the exploratory survey. The exploratory survey helps in the design of the formal survey by:

a) identifying important topics bearing on research planning that should be the focus of the formal survey;
b) ensuring that written questions in the formal survey are asked in a way that can be understood by farmers;
c) designing and testing a sampling scheme;
d) publicizing the forthcoming research program including formal surveys and experiments.

For these reasons we emphasize that a good exploratory survey must be undertaken in order to design a well-focused formal survey.

Further, the exploratory survey is used to collect important information that may be too sensitive or complicated to include in a formal survey. With researchers themselves asking the questions in informal conversations, more complex dialogues can be pursued. Examples of such information are: the way farmers reason about particular problems, interest rates and borrowings in the informal credit market, and crop sales.

Finally, while we stress the need for an exploratory survey at the beginning of the research work, the type of informal researcher-farmer dialogue described in this chapter should be a continuous process through all phases of the program.

6.2 The Exploratory Survey Process

The exploratory survey is a continuous learning process of assembling information on farmer circumstances against the checklist in Chapter 3, evaluating the information obtained to determine where further efforts should be focused, and then returning to the field to obtain this information. The exploratory survey is a gradual process of focusing on the key issues for experimentation. Initially the researchers should begin with an open mind about what are the key problems limiting productivity. As the survey proceeds the checklist is narrowed by eliminating information that is not relevant to understanding farmers' practices in the area. Finally, a tentative list of problems and potential technologies is drawn up and information narrowed to variables and relationships needed to prescreen these technologies for inclusion in the experimental program.

The exploratory survey is conducted by the researchers themselves—the agronomist and the economist—working as a team. They traverse the target region, observing farmers' fields and interviewing farmers and other persons with specialized

knowledge of agriculture in the area. It is best done when the target crop is in the ground so that problems can be observed in the field. It is also most efficiently implemented in a single recommendation domain or at least a target region which has previously been identified as being relatively homogeneous with respect to farming systems and practices, to allow researchers to focus their efforts on a common set of problems.

The amount of time spent on the exploratory survey will vary from one to three weeks depending on the size and complexity of the region and the previous local knowledge of the researchers. *It is our experience that researchers rarely spend sufficient time on this rewarding and essential task.*

The bulk of the exploratory work will consist of interviews with farmers. An effort should be made to interview a broad cross-section of farmers. Farmers who hold positions of traditional leadership can usually give a good description of local farming practices and often have very useful perceptions about the reasons behind these practices and how these practices have changed over time. Farmers identified by the extension service will often have tried recommended technologies and therefore will have information and opinions about problems and potentials for these technologies. So-called "innovative" farmers, or farmers who have successfully developed their own improved technologies will be valuable sources of information on potential technologies for farmers in the area. Finally, efforts should be made to identify farmers who are roughly representative of the region. These farmers are best identified by chance—that is, farmers that researchers meet in the field, on roads or walking paths, or in the village.

Group interviews can be particularly valuable in obtaining a general description of farmers' practices and reasons for those practices. However, groups should be kept relatively small (say four to six farmers) in order to arrive at answers to questions relatively quickly.

Interviews should be conducted in a relaxed manner. An in-depth interview is best conducted in a place in which the farmer is most comfortable such as sitting down in his house or under the shade of a tree in the field. Use of a pencil and papers should be restricted although notes may be taken on quantities, names of products, varieties, etc. However, all relevant information should be immediately noted down after leaving the farmers. It may also be possible for one member of the research team to take more extensive notes during the interview while the other member conducts the bulk of the interview. This saves time in writing notes after the interview.

Because of the informal nature of the survey, little difficulty is usually experienced in gaining farmers' cooperation as long as researchers are respectful toward farmers. In fact, our experience has shown that farmers are usually extremely cooperative toward this type of interview and enjoy the interest shown by researchers in their farming methods and problems. The ability to communicate with the farmer in commonly understood terms is also important. In the case of a longer, more structured interview, the purpose of obtaining the information should be first explained; otherwise the interview can be conducted as a conversation with a passing farmer. However, it will not be worthwhile in an exploratory survey where farmers are not randomly chosen to try to convince an uncooperative farmer to be interviewed—rather another farmer should be sought. (Chapter 9 provides more discussion on gaining the cooperation of farmers).

Efforts should be made to identify the primary decision maker in the household with respect to a certain crop or practice. For example, if women are responsible for weeding maize, then it will be desirable to talk to women to discuss weeding practices. In some cultures this may be difficult if all research team members are male.

Interviews with farmers will range from a casual conversation on one or two topics to in-depth interviews over a broad range of topics. Clearly, it is possible to cover only a part of the information in our checklist in one interview with a farmer. What information is included will depend on what practices a farmer is following, the problems he is experiencing and the degree of cooperation encountered. For example, a farmer who is experiencing difficulty in completing the quantity and quality of weeding desired (observed in the field visit) might be asked detailed questions about the hired labor market, competing labor demands in other crops, timing of operations, etc. A farmer who is particularly cooperative might provide information on several topics, including sensitive information such as cash flows and loans. In general, it is useful to ask some general questions about the target crop and the farming system and then use the responses to decide what specific areas will be emphasized.

It is not necessary to focus the questions on the practices of a specific farmer. In fact, much can be gained—particularly in interviews with traditional leaders—by discussing practices commonly followed by farmers in the area. For these

types of questions, interviews with groups of farmers can be particularly valuable in gaining rough estimates of the frequency of use of various practices.

The farmers' knowledge and opinion of current recommended technologies are very useful in identifying those critical circumstances that have been most important in accepting or rejecting components of these technologies. This is particularly the case if farmers have tried a practice and then rejected it. This is clear evidence that the practice did not accord with farmer circumstances. Reasons why this was so provide valuable guides in designing more appropriate technologies.

Field observations are very useful in the exploratory survey. Here the efforts of the research team agronomist will be particularly important. However, field observations need to be complemented by questions to farmers. The interpretation of problems in the field often depends on a knowledge of farmer practices such as previous crop, time of planting, variety, and time and method of weed control. Also farmers may see a problem from a different point of view. In many areas they recognize yield losses from weeds but also value weeds as fodder. Furthermore, the problems observed in a field at one point in time in one crop cycle may occur only rarely. Questions can be directed to farmers to determine other problems or the frequency of a given problem over the years.

In order to conduct field observations it will, of course, be necessary to time the exploratory survey during the growing season of the target crop. Also researchers must allow time for walking to the farmers' fields. One sequence that we have found useful is to conduct an in-depth interview with a farmer (or group of farmers) in the village and then to accompany the farmer to his field. This usually allows fields of neighboring farmers to be observed as well as short interviews to be made with other farmers met on the way.

In addition to farmers there will be many other persons in the region who can provide valuable information on specific aspects of farmer circumstances and/or can help in implementing the exploratory and formal surveys. Local government officials should be contacted early in the survey to ensure that they are familiar with the scope and purposes of the research program. A failure to inform officials of any local institution which have influence with local farmers jeopardizes the success of the program. Local officials can also be useful in planning the formal survey. They may be able to help develop lists of farmers or villages for sampling, recruit local interviewers and find accommodations for interviewers.

In any area there are a number of people who are linked to local farmers and who have specialized knowledge of some aspects of local farmers' circumstances. These include (a) agricultural extension agents, (b) government marketing agents and private buyers, (c) input suppliers, (d) machinery contractors, (e) bankers and credit agents and (f) land reform and irrigation agencies. Marketing agents can provide information on marketing channels, seasonal and annual price variation and marketing margins. Extension agents can provide experiences with recommended technologies. Input suppliers know the availability and sales volumes of various products.

As a general rule, we suggest talking to people who are particularly knowledgeable of local agriculture at the beginning of the survey to gain an overview of agriculture in the target region. Interviews with institutions serving agriculture should then be conducted towards the end of the survey, using as a guide to questioning the farmers' perspective on the operation of these institutions.

6.3 Assembling Information in the Exploratory Survey

The assembly of information in the exploratory survey follows the checklist given in Chapter 3 although not necessarily in that order. Information on production practices of farmers is collected at two levels. First we want to know what are the general practices of farmers in the area. Second, for most practices we find it useful to explore variations in the practices with respect to (a) variation across farmers in the region, (b) variation across years and seasons and (c) long-term trends. In each case, trying to understand why such variation occurs will help in understanding why farmers use certain practices. Variations among farmers help in defining recommendation domains. Variations across years are important to assess farmers' risk-management strategies. Long-term trends (i.e. those traditional practices that are being discarded and those new practices that are becoming common) help establish how farmers are reacting to a changing external environment (such as population pressures or market opportunities).

This description of farmer practices is, of course, part of the effort to understand why farmers follow certain practices. Researchers will already have some secondary data on some of these influences which will guide the assembly of information in the exploratory survey. For example,

if it is known from secondary data that the maize area is decreasing, then some attention will be given to farmer circumstances that might be leading to this decline.

Natural circumstances affect practices through defining the potential for the crop in the region and through risk. In many situations, it is the risk element of natural circumstances and how farmers react to this risk, which will require emphasis in the exploratory survey. On the economic circumstances, emphasis is placed on identifying those circumstances which create particular constraints and/or risks for farmers. For example, what inputs are not available when needed; under what conditions is credit available; or when do high prices and poor availability of the food staple occur. Of course, natural and economic circumstances influencing farmers' practices cannot be analyzed separately since there will often be important interactions. The example cited earlier in which farmers weed maize late because they are planting beans is a situation in which the natural disease circumstances dictate the planting time of beans, while economic circumstances of labor shortages lead to late weeding of maize.

The guiding principle in assembling information on farmer circumstances to explain farmers' practices should be that if a significant number of farmers in a region are using a particular practice, farmers have a good reason for using that practice. That is, farmers in choosing to use a given practice are rationally reacting to elements of their natural and economic circumstances and it is the challenge to the researchers to uncover what are those circumstances. The easy solution is, of course, to assume that farmers use an apparently "bad" practice because they are irrational, traditional or ignorant; then we can ignore those practices in the design of improved technology. Unfortunately, all too often we will find that the farmer will not use the "improved" practices because they conflict with the very circumstances that we originally failed to understand.

After each days' work, it is helpful to discuss what has been learned, formulate new hypotheses and determine what are the key gaps and conflicts in their understanding which should be explored in further interviews. Information should be organized along the lines of the checklist of Chapter 3 in order to help identify gaps. Also as the survey proceeds, a list of problems and potential technological components for experimentation should be developed in order to focus information on that relevant for research decision making.

6.4 Integration and Evaluation of the Exploratory Survey Data

As the exploratory survey continues, the information obtained is integrated and evaluated to guide further exploratory survey work and to design the formal survey.

Refining Recommendation Domains: The variation in farmer circumstances in the region is a basis for refining recommendation domains. A useful starting point is to note major variations in current farmers' practices (including cropping systems) in the region. These variations are then related to the circumstances hypothesized to influence the particular practice (see Example 6.1). Recall, however, that we are only interested in variations that might make a substantial difference in recommendations to farmers. Where such variations exist but are very gradual, the boundaries of recommendation domains will be arbitrary. For example, rainfall variations are often quite gradual over a region so that there will be no sharp distinction between wetter and drier areas.

Description of Present Practices: The researchers, as a result of their informal interviews, should establish for each recommendation domain a list of management practices used for the target crop as well as for other crops and activities in the farming system which impinge on the target crop. They should note the apparently widespread practices as well as those which vary considerably in the area. They should attempt to establish the characteristics of farmer circumstances which seem to be associated with the use of a given practice. Toward the end of the exploratory survey, it should also be possible to give approximate frequencies of use for a given practice among the target population (e.g., 0-10 per cent, 10-25 per cent, 25-50 per cent, 50-75 per cent, 75-100 per cent of farmers).

Hypotheses to Explain Present Practices: An important part of the exploratory survey is to formulate hypotheses on reasons for farmers' practices. In many cases several circumstances may bear on a particular farmer practice. For example, in one area farmers were found to stagger their planting of maize, usually making three plantings in a season. Three hypotheses for this practice in tentative order of importance were formulated: (a) a larger area can be planted as labor is a limiting factor at the planting period, (b) there is a dry period three months after the start of the rains and late plantings may survive this period better than plantings that flower at that time, and (c) early plantings give an

[illegible]

[illegible] tude increased among irrigated farms, the vegetative cycle became longer and planting dates later (to avoid early frost). Associated with these changes, however, was a decrease in a leaf disease problem of maize, one of the factors limiting yields. At the lower altitudes there was also a small group of farmers, near a large town, who sold green maize resulting in somewhat different practices. Finally there was a small group of [illegible]

Recommendation Domain	Altitude (m)	Irrigated/ Rainfed	Main Planting Dates	Vegetative Cycle (days)	Disease Incidence	Maize Disposal
I	2400-2600	Irrigated	Aug-Oct	150	Very high	Sold as green maize
II	2600-3000	Irrigated	Sept-Nov	180	High	Subsistence grain
III	3000-3500	Irrigated	Oct-Nov	210	Mod.	Subsistence grain
IV	2600-3500	Rainfed (300-600 mm)	Nov-Dec	195	Mod.	Subsistence grain

early supply of new food and are particularly important when the previous harvest has been poor.

In another area with two maize crops per year, maize was observed to be harvested well past the point where the grain was considered dry enough for harvesting under normal conditions. To account for this practice it was hypothesized that a labor shortage existed at the normal harvesting time because of the need to plant the next cycle's maize.

In both examples the tentative hypotheses help formulate questions for the formal survey to test each hypothesis. In the first example, questions were included in the formal survey on labor availability at planting time, crop losses for each planting due to drought, seasonal food supplies and farmers' response to a poor harvest.

Practices and priorities of other activities in the farming system may also influence management practices for the target crop. In one short-season maize area with increasing population pressure, it was found that farmers were often planting late, well after the rains had started, resulting in reduced yields. It was hypothesized (in discussion with livestock officers of the area) that because of the reduced grazing area and feed shortages at the end of the dry season, oxen were weak at the preferred period of land preparation and farmers were delaying ploughing until the rains had softened the ground, to make ploughing easier for the oxen. The formal survey

was designed to test the hypothesis by including questions on trends in ownership of oxen and forage availability.

Prescreening of Technological Components: The prescreening of technological components that can potentially solve identified problems is discussed in detail in Part III where data from both the exploratory and formal surveys are utilized. However it is useful to begin the prescreening process in the exploratory survey in order to sharpen questions for the formal survey.

A list should be drawn up of factors limiting production and incomes and of potential management components to overcome these constraints. Each new or potentially new management component is evaluated in the light of the difference between it and the present practice. Hypotheses are developed on the feasibility of changing each management component from the present to the new practice. This process yields two sets of hypotheses: on reasons for present practices and on the acceptability of the changed practices (see Example 6.2). These can be tested and verified in the formal survey.

Designing the Formal Survey: The exploratory survey work has as an important objective the design of a formal survey of farmers in the region. Most importantly, it narrows down the data to be collected in the formal survey to that which are essential for understanding present practices and prescreening technologies. In this way the questions in the formal survey are sharpened. The exploratory survey work should also be used as a vehicle for (a) designing a sampling frame, (b) publicizing the formal survey and (c) determining local terminology and measures, all of which contribute to the success of the formal survey.

Example 6.2: Tentative Prescreening of Technologies

In one maize-growing area weeds were identified as a major factor limiting production. The exploratory survey established that the first weeding was being conducted after weeds had already done much damage. It was hypothesized that a labor shortage and wet weather conditions often prevented timely weedings. Researchers felt that a pre-emergence herbicide applied at the time of planting would offer potential benefits to farmers. As a result, the formal survey focused on information which would be needed to evaluate the suitability of such a herbicide. Questions were related to factors such as time of weeding, labor required for weeding, use of hired labor, intercropping practices and cash availability at planting.

Example 6.3: Implementing an Exploratory Survey

An exploratory survey was conducted in a maize-producing area over an eight-day period. The team, consisting of an agronomist, an economist and part of the time the supervisor of the local extension service, had access to a vehicle during the entire period. Prior to the survey secondary data had been gathered on rainfall and soils, crop areas and yields and population density as well as maps of the area of scale 1:100,000.

The team was based in a town that was the administrative center of the region and each day traveled to a different part of the region. Initial emphasis was placed on in-depth interviews, often lasting up to two hours, with village leaders to obtain a general picture of agriculture in the region. Some villages were chosen to represent those in which government production programs had operated but most were chosen by chance from a detailed map of the area. With time, more effort was made to schedule both short and in-depth interviews with farmers met by chance and to interview those involved in maize marketing and government officials of local government [illegible] banks and input suppliers.

All interviews were [illegible] occasional notes taken by [illegible] More complete notes were [illegible] after leaving the site of the [illegible] the [illegible] assembled information [illegible] checklist similar to [illegible] page of the report [illegible] such as [illegible] ration, variety, [illegible]

Continued

SELECTED FURTHER READINGS

CHAPTER 6

1. Hildebrand, Peter, "Summary of the Sondeo Methodology used by ICTA," Instituto de Ciencia y Tecnología Agrícolas, Guatemala, C.A., June, 1979.
(Describes the methodology of an informal survey approach to understand farmer circumstances in a situation in which no formal survey is used.)

2. F.C.L.M. Lihanda "Adaptive Research Planning: A Case Study, Vihiga Division, Kenya." CIMMYT Eastern African Economics Programme, 1978.
(Reports the results of an exploratory survey.)

3. Bruce, K., D. Byerlee and G. Edmeades, "Maize in the Mampong-Sekodumasi Area, Ghana: Results of an Exploratory Survey." CIMMYT Economics Working Paper, 1980.
(Reports methods and results of an exploratory survey used to design an on-farm experimental program.)

chapter 7 the formal survey questionnaire

The purpose of the formal survey is to verify and quantify information and test hypotheses formulated in the exploratory survey. Variations in farmer practices in the region can be quantified and hypotheses or reasons for the use of these practices can be more formally tested. The essential characteristic of the formal survey is that a uniform set of data is obtained from a relatively large number of farmers that as a whole are representative of the region. This is achieved through the use of a written questionnaire, discussed in this chapter, and a random sample of farmers, discussed in the next chapter.

We emphasized in the previous chapter that the questionnaire is developed on the basis of the exploratory survey. There is no "standard" questionnaire for this type of survey, but rather the questionnaire is specific to a given region and set of research objectives. The questions included in the questionnaire arise from focusing the exploratory survey onto the important information needed for planning experiments. Nonetheless, given the general objectives for describing farmer circumstances outlined in Chapter 2, most questionnaires will have some sections in common. For example, to obtain information on representative practices of farmers to be used as a basis for on-farm experiments, the questionnaire will normally include a section on the timing and methods of farmers' practices—from land preparation to post-harvest operations—for the target crop However, the specific information solicited will vary from area to area. Surveys in irrigated areas, for example, will include questions on water management.

In this chapter we provide some general principles for developing the formal survey questionnaire. Many examples of questions are included to illustrate these principles. Once again we emphasize that each example was developed for a specific situation and these examples are not necessarily intended for general use.

7.1 General Rules for Developing a Questionnaire

Organizing the Questionnaire: Questions should be included in a sequence that begins with specific questions on crop practices which the farmer will find easy to answer and proceeds to more sensitive and difficult questions. Here is a suggested sequence:

(a) Screening questions to determine if the farmer fits the requirements of the sample. For example, if the sample is restricted to producers of the target crop, a question is included to find out if that farmer grows the crop.

(b) Facts about management practices used on the target crop (i.e., land preparation to post-harvest operations including use of inputs).

(c) Opinions about specific management practices and the severity of hazards, problems and constraints for the target crop.

(d) Facts about disposition of the target crop, e.g. yields, marketing, storage and use of crop residues.

(e) Important facts and opinions about the total farming system which bear on the target crop, e.g. labor bottlenecks, crop sequences and rotations, livestock manure for crops, food preferences, seasonal consumption patterns and cash flows.

These groups of questions should be organized into sections of the questionnaire in such a way that the questionnaire has a logical flow. There should be no need to frequently change topics or to flip pages back and forth during the

interview. At the beginning of each new section of the questionnaire there should be a sentence for the interviewer to introduce the topic. For example, the section on crop disposal might be introduced as follows: "Now we would like to talk about how you use the maize that you produce."

Language of the Questionnaire: It is common to find that the language spoken by farmers differs from the official language of the country or region. If this is the case the questions should be asked in the local language by an interviewer whose native tongue is that language (see Chapter 9). If the spoken language is widely *written* in the area, the questionnaire should be written in that language. Otherwise, the questionnaire should be written in the common written language and translated by the interviewer during the interview. In both cases the translation should be thoroughly checked, preferably by a senior researcher proficient in both languages. In particular, questions that solicit opinions have to be very carefully translated to ensure that the meaning of the question is correctly conveyed.

Length of the Questionnaire: The length of the questionnaire depends on the objectives of the survey and the complexity of the farming system in the area of study. As a general rule the questionnaire should be completed in less than 90 minutes to avoid fatigue on the part of the farmer. In our experience, a thorough exploratory survey enables the design of a questionnaire that can be completed in about one hour. It is desirable to avoid trying to obtain information for several objectives in the one survey. Rather the quality of the information is improved if we focus only on important information useful for agricultural research decisions.

The length of the interview can also be reduced by subsampling from the main sample for parts of the questionnaire which are not strongly interrelated and for which a smaller sample size would suffice. For example, in one survey researchers felt they wanted more in-depth information on two topics: marketing activities and family labor used in off-farm work. The questionnaire was designed so that one half the sample, chosen at random, was asked in detail about off-farm work and the other half was questioned on marketing activities.

7.2 General Guidelines for Asking Questions

There are several guidelines to keep in mind in asking individual questions. The questions should be written as they are to be asked. (This does not mean that the interviewer should read the questions). Factual questions should be specific to a particular crop season. For example ask, "Did you apply fertilizer to wheat this year?" rather than, "Do you use fertilizer on wheat?" This latter question will tend to give a bias toward fertilizer use, since the farmer will often answer positively even if he only rarely uses fertilizer. However, it may also be useful to explore whether a practice is normally used, especially if substantial year-to-year variation was noted in the exploratory survey.

Questions must be asked in a way that is easy for the farmer to answer. For example, allow the farmer to express his crop production and area in local units rather than standard kg/ha units. The conversion to standard units should be made *after* the interview.

It is nearly always preferable to permit *open responses* where the farmer answers in his own words. However, *precoded* questionnaires are an efficient way to record open responses. An example of a *precoded open response* is:

"What did you do with the crop residues after harvest?"

Burned it _____
Ploughed it in _____
Left it on top of the soil _____
Fed it to the animals _____
Other (specify) _____

In this example the farmer is given an open response question but several likely answers (based on the exploratory survey) are provided and the interviewer simply marks the appropriate response thus saving time in writing. The precoded question also ensures that the interviewer elicits a specific answer. Note, however, that precoded questions should include "Other (specify)" to record unusual answers (e.g. the farmer sold the residues).

Tables are a convenient way to ask sets of similar questions to obtain *factual* information. Examples 7.1 and 7.2 illustrate the use of tables to collect information on production practices and crop calendars.

[illegible]

(For the Interviewer: Obtain the following information for the identified field for this season)

Operation	Operation Performed	When	Method	Implement Used	Is Animal or Tractor Rented/ Owned?
Ploughing	Y/N	____ 1234	M/A/T	_____	R/O
First Harrowing	Y/N	____ 1234	M/A/T	_____	R/O
Second Harrowing	Y/N	____ 1234	M/A/T	_____	R/O
Third Harrowing	Y/N	____ 1234	M/A/T	_____	R/O
Seeding	Y/N	____ 1234	M/A/T	_____	R/O
Covering	Y/N	____ 1234	M/A/T	_____	R/O
Others (sp _____)		____ 1234	M/A/T	_____	R/O
KEY	Y=Yes N=No	Put Month & Circle Week of Month	M=Manual A=Animal T=Tractor	Specify Implement	R=Rented O=Owned

7.3 Guidelines to Obtaining Specific Types of Information

Some types of information are difficult to record and will often be unreliable unless special precautions are taken. These problems arise for two reasons. First, the farmer may not know the answer to the question because he can't remember (e.g., amount of labor used for an operation) or because he is not accustomed to quantifying the variable in question (e.g., land area in some regions). Second, the farmer may know but does not give the correct information because the question is not asked properly (e.g., "How many days did it take you to plant this field of wheat?" may not elicit mandays of labor provided by helpers), or because of the sensitive nature of the information (e.g., data on loans, sales, etc).

In many cases these problems can be avoided by careful questioning. In some cases it may be necessary either to omit this information or to employ more costly methods if the information is really needed. Some guides for obtaining specific types of information are given in the following sections.

Crop	Planting (Check each)	Month Started Planting	Month Completed Planting	Variety	Type of Seedbed M/R/F/a/	Area (approx)	Month of Use from Field b/	Month of Crop Harvest
Maize	1							
	2							
	3							
	4							
Beans	1							
	2							
	3							
	4							
Finger Millet	1							
	2							
Sweet Potato	1							
	2							
Cassava	1							
	2							
Old Cassava c/								

a/ M=Mounds, R=Ridge, F=Flat
b/ Note month when begin using new crop [illegible]
c/ For old cassava—give month and year planted

Land Inputs: In some traditional agricultural areas, particularly in areas where the bush-fallow system is used, farmers may not have a measure of the land area (either in local or standard units). In this case it may be desirable to measure the area of the target crop at least for a subsample of farmers since a good deal of other information on input use and production must be expressed on a per area basis to be meaningful. Methods using a compass and tape are quite cheap although time consuming. Further readings at the end of this chapter provide references describing various field measurement methods. Note, however, that a decision to measure field areas even for a smaller number of fields will add substantially to the resources required for the survey (or reduce the sample size) and the additional precision obtained must be balanced against these costs.

Labor Inputs: Accurate labor input data are almost always difficult to collect in one interview because it is almost impossible for farmers to recall precisely labor inputs for specific crop operations. For the purposes of planning technologies, labor information may be needed for specific crop operations affected by potential technologies or for determining seasonal labor constraints in family labor use.

All new technologies require some changes in farmers' labor inputs. Fertilizers require labor for application. Herbicides substitute for labor for hand weeding. Increased yields require additional labor for harvesting. Labor inputs for some operations are therefore required for prescreening technologies for experimentation and for making farmer recommendations on the basis of the results of these experiments. *Note that this is not a cost of production study and therefore only labor inputs affected by technologies being considered should be collected in order to keep the questionnaire manageable.*

An approximate estimate of specific labor inputs can be made by carefully questioning the farmer about the labor usually required for an operation per unit of area or for a given field (see Example 7.3). The error can be reduced by ensuring that the farmer 1) is familiar with the unit area or field referred to; 2) includes all labor (himself, family, hired) and particularly labor that is often overlooked such as transporting inputs to the field, 3) understands that the question refers to units of adult labor; 4) understands clearly the operation in question, (e.g., is it labor for the first weeding or all weedings?); 5) identifies operations which are performed simultaneously (e.g., a fertilizer application at the same time as planting or weeding).

A second important aspect of labor use in areas of relative labor scarcity is the existence of periods of the year when family labor is fully occupied and of other periods of slack labor. Knowledge of when these periods occur is important in promoting new technologies since it is desirable to promote technologies which reduce labor requirements at busy periods and utilize more labor during slack periods. However it is impossible to construct a detailed labor profile for the whole farm household for the whole year in one interview and a simplified approach is suggested and illustrated in Example 7.4. First the busy period of the year is identified by asking farmers the months when there is the most work to be done. Then the tasks must be identified that have to be performed during those months, both on the farm and off the farm. This will provide a good picture of what operations the

	No. Men Who Normally Weed This Field	No. Days If All Men Work a Normal Day
First Weeding		
Second Weeding		
Third Weeding		

farmer would have to reduce in the busy period in order to adopt a technology which requires added labor during this period. Information on what tasks the farmer feels he has difficulty completing on time also helps in identifying labor constraints.

Purchased Inputs: It has been our experience that data on inputs such as seed, chemicals and equipment require special care. Some rules to follow are:

a) be familiar with local units to be sure that the quantities expressed in local units can be converted to standard units. Also ensure that actual and not recommended rates are reported;

b) check that the input was applied to the total field and not to a part of the field;

c) for chemical inputs ask the number of applications and find out if the quantity applied is for one or for all applications;

d) find out the type of input. Often in the case of fertilizers and chemicals it will be necessary to look at the container.

Example 7.5 reproduces a part of a questionnaire used to obtain data on insecticide use in maize.

Field Versus Crop Data: In areas where farmers commonly have more than one field of a given crop, a decision has to be made whether data on crop management practices are to be collected by crop or by field and, if by field, for some or for all fields. Again the exploratory survey must be used to make this decision. If it appears that fields of the crop are similar with respect to location, topography, soils and rotations, and farmers are applying the same practices to each field, then information by crop will be satisfactory. On the other hand, if fields differ physically or in management practices, then data should not be collected by crop. In this case, data can be collected

Example 7.4: Determining Seasonal Labor Constraints

For a tropical maize-growing area with two crops of maize per year, the following questions were asked:

"In what months or period of the year do you and your family have to work hardest?"

Jan ____ Feb ____ Mar. ____ April ____ May ____ June ____
July ____ Aug ____ Sep ____ Oct ____ Nov ____ Dec ____

What work is done in these months/periods?

Month/Period	Crop and Task	Usually Completed on Time?
1. _____	1. _____	1. _____ Y/N
	2. _____	2. _____ Y/N
	3. _____	3. _____ Y/N
2. _____	1. _____	1. _____ Y/N
	2. _____	2. _____ Y/N
	3. _____	3. _____ Y/N

Example 7.5: Recording Information on Input Use

In one tropical maize area it was found in exploratory survey work that farmers applied insecticides several times each cycle but often used different insecticides and dosages on a variable part of the crop. Information for each application was collected in tabular form as below:

Application Number	Name of Insecticide	Where Purchased	When Applied	Dose/ha	Number of Hectares Covered
First					
Second					
Third					

on a field basis, but it is time consuming to collect information individually for more than two or three fields. In some cases fields of similar characteristics can be merged into groups. For example, during the exploratory survey in one area farmers were found to be making two separate plantings of maize—one for early green maize consumption and the other primarily for sale of grain. In the formal survey, information was collected for each planting—regardless of the number of fields in each planting. Finally, we have generally found it easiest to collect detailed information on practices for a specific field representing the major production system used by the farmer. This detailed information can be complemented by obtaining only important information such as planting dates or variety on all other fields of the crop.

Rotations/Multiple Cropping Patterns: Farmers' desired rotation and cropping patterns over time often differ from what they actually practice. For example, they may desire a wheat/oats/fallow rotation but in practice they often change because of weather conditions such as drought or because of specific cash needs. Therefore, in addition to asking general rotation practices, it is often necessary to trace the history of a specific plot to determine how land is being used over time. Example 7.6 illustrates this type of question.

Agronomic Data: Agronomic data on density, intercropping practices, nutrient deficiencies, soil type, germination problems, type of weeds and incidence of diseases and insects are useful for diagnosing agronomic factors limiting production. Generally, this information can best be obtained by direct observation in the farmers' fields. If the interview is conducted in the farmers' fields during the growing season, then interviewers can be taught to estimate variables such as soil color and texture, per cent damaged plants (with reasons for damage), extent and type of weeds and, in the case of maize, planting density (see Example 7.7). The interviewer should ensure that the observations are taken in a representative part of the field.

Many agronomic problems occur in different stages of crop development. In our experience, field visits at the stage of flowering in maize or wheat have been the most timely. However, even here, there is usually a need to ask the farmer supplementary questions about other stages of the crop (e.g., leaf diseases which appear near crop maturity or insect/disease problems of the ear). The farmer will of course have a local name for the insects, diseases and weeds which should have been noted in the exploratory survey. Finally, it is useful to supplement the field observations by asking farmers whether particular problems noted in the field are also common in other seasons.

Production and Yield: Production and yield figures given by farmers are often quite unreliable particularly where (1) there are no standard units of measure, (2) the crop is continuously consumed, sold or used to pay labor over the harvest period, or (3) taxation or local custom makes this sensitive information.

In surveys for the purpose of planning experiments, accurate production and yield data are usually not essential. In areas where farmers are familiar with the concept of yield, direct questions will provide an approximate yield. In other cases rough estimates can be obtained by carefully asking questions about various end uses of production such as amount stored, consumed, sold, given as labor payments, gifts, etc. Yield estimates obtained through these methods are useful to provide a guide to average farmer yields and their variability. They will not be

Example 7.6: Recording Information on Crop Rotations

In a tropical maize-growing area a complex system of intercropping and relay cropping was practiced. The following table elicited the three-year history of one field (usually farmers only planted one field to maize in a given season).

"For this maize field please list the crops that you have planted in this field in the last three years. Begin with the previous crop."

	Crop	[illegible]
Previous Crop:	_____	_____
	_____	_____
	_____	_____
	_____	_____

Example 7.7: Prescreening Information Gathered in Field Observations

The following agronomic data were collected by interviewers in farmers' fields. Particular emphasis was placed on training the interviewers in choosing representative sites in the field and identifying weeds, pests and insects:

"If the interview is conducted in or near the farmer's field, choose a representative part of the field and take the following observations."

1. Density: In the farmer's field, choose four representative points at random and take the following data at each point. (Tape measures are provided for this purpose.)

Sample	Distance between 5 hills	Distance between 5 rows	Number of plants in 5 hills
1			
2			
3			
4			

2. Weeds
   a) Most important weed types (e.g., broad leaf, narrow leaf, perennial, annual) _____
   b) Percentage of control [illegible] _____
   c) Height of the weeds _____

3. Insects
   a) Insects currently present _____
   b) Insects that were present and caused damage _____
   c) Insect damage: Serious _____ Some _____ Not important _____

4. Diseases
   a) Diseases currently present _____
   b) Disease damage: Serious _____ Some _____ Not important _____

5. Soils
   Color _____ Texture _____

6. Topography
   Flat _____ Sloping _____
   Steep _____ Hill top _____
   River flood plain _____

7. Nutrient deficiencies observed: _____

8. Other observations _____

suitable for trying to explain yields in terms of the practices used by farmers. Where accurate yield data are required, direct measurement techniques are available and are described in further readings listed at the end of the chapter.

Other uses of a crop output are often forgotten—for example, uses of weeds, crop residues and leaves for animals. Sometimes it will not be possible to quantify this output but it is important to take note of such practices for the evaluation of technologies which might affect these by-products.

Finally, experience shows that farmers generally underestimate sales data since they concern cash inflows and are considered sensitive information. Because of this, data on subsistence grain consumption, estimated as the difference between production and sales, are correspondingly inflated and should be treated cautiously.

Cash Flows: Information on cash flows is difficult to obtain because of its complexity and sensitivity. However, for the purpose of prescreening technologies, it is sometimes useful to know the time and level at which cash constraints occur in the cropping season. A knowledge of the farming system obtained in the exploratory or formal survey—what crops and livestock products are sold and when as well as participation in nonfarm work—will provide a rough guide. More direct methods can be used as shown in Example 7.8.

Subjective Data—Obtaining Farmers' Opinions: Information on what farmers do is objective and usually quantifiable. However, subjective data on farmers' opinions and perceptions about problems and technologies require different handling. The identification of major problems perceived by farmers is done in the exploratory survey. The role of the questionnaire is to obtain estimates of how widespread are those problems and opinions and whether there are differences between groups of farmers. Therefore it is not usually useful in a formal survey to ask broad questions about the problems in producing a given crop. The questions should be much more specific. For example, what

SOURCES	Maize Sold	Bean Sold	G/Nut Sold	Banana Sold	Fruit, Veg. Sold	Other prod. Sold	Chickens Sold	Eggs Sold	Family work.	Govt. work	Shop Trade	Casual Labor	Pension	Other
Received Cash (Check)														
Period Received														
All through the year														
Irregularly														
Jan-April														
May-August														
Sept-December														
Approximate Level														
Less than 10 -$-														
10-30 -$-														
30-50 -$-														
50-100 -$-														
100-200 -$-														
200-300 -$-														
300-400 -$-														
More than 400 -$-														
Amount unknown														

are the best varieties with respect to yield, storage, processing, drought tolerance, disease and insect resistance, or what are the advantages of applying fertilizer after planting. Farmers may also be asked to express preferences about varieties. Do they prefer earlier (later) varieties to higher yields and why? Subjective questions should be asked in a way that show respect for the farmer's practices. Questions such as "Why do you intercrop?" are asked from a biased viewpoint of researchers who work only with monocultures.

Examples 7.9 and 7.10 show questions that were successful in obtaining subjective data. Both these examples depend on a thorough exploratory survey in order to list the problems and opinions that should be included in these questions.

variety?

Doesn't fall over with the wind _____
Early maturing _____
Better yield _____
Tastes better _____
Other (sp) _____

(These questions were then supported by some comparisons between C16 and the local variety where the enumerator recorded the farmer response with a check)

	C16	Local Variety	No difference
Which variety yields better when there is a drought?			
Which variety yields better when there are strong winds?			
Which variety matures earliest?			
Which variety stores well for the longest period?			
Which variety makes the best Irio (local maize food)			

Example 7.10: Obtaining Farmer Opinions on Climatic Hazards

The importance and frequency of various climatic hazards to tropical maize was gauged from the following questions:

1. "Which was the worst season for farming over recent years?"

	1979	1978	1977	1976
Long rains	____	____	____	____
Short rains	____	____	____	____

2. "What was the main *cause* of these difficulties?"

_____

_____

3. "Why was this the worst season and what was the effect on you and your familiy?"

_____

_____

_____

4. "In which years recently have you experienced the following problems?"

	This Season	79	78	77	Not a Problem
1. Heavy late rains rot maize ears					
2. Heavy early rains spoil maize seeds in the field giving poor germination					
3. Early finish to rain so that maize matures poorly					
4. Poor germination of finger millet					
5. Early finish to rains—late planted beans fail					

7.4 Finalizing the Questionnaire

On the basis of a thorough exploratory survey a good questionnaire can be developed. Still, it is always necessary to pre-test the questionnaire before producing a final version. This pre-testing enables the researchers to determine which questions are not easily understood by the farmer and therefore should be redrafted, to check the time required for completing the questionnaire, and to test the sampling procedure.

The adequacy of the data in the questionnaire should be pre-tested by going to the field to interview five or so farmers. Some or all of these farmers may be selected to pre-test the sampling procedure as well. The researchers must conduct or be present at these interviews so that they can better note the problems and determine the necessary revisions.

After the pre-testing, it is useful to tabulate the responses using the methods of data tabulation suggested in Chapter 10. This will be a test to ensure that the data provided by the questionnaire satisfies our needs for information on farmer circumstances.

SELECTED FURTHER READINGS

CHAPTER 7

1. Kearle, B. (ed.), *Field Data Collection in the Social Sciences,* Agricultural Development Council, 1976. (Chapter 5 discusses issues and experiences in questionnaire development in Africa.)

2. Bernsten, R., *Design and Management of Agricultural Research: A Guide for Agricultural Researchers,* Draft Paper, International Rice Research Institute, 1979. (Offers useful guides to questionnaire development.)

3. Collinson, M.P., *Farm Management in Peasant Agriculture,* Praeger, New York, 1972. (Discusses methods for collection of specific types of data, especially land, labor and output.)

4. Norman, D.W., "Methodology and Problems of Farm Management Investigations; Experiences from Northern Nigeria," African Rural Economy Paper No. 8, Michigan State University, 1973. (Reviews experiences in questionnaire development for conducting farm level studies.)

chapter 8 sampling for the formal survey

Before beginning a survey a basic decision must be reached about the *population of farmers of interest.* Generally we are interested in improving technologies for those farmers currently growing the crop. Sometimes our interest is broader. If the target crop is a new crop or not widely grown, the population of interest are all those farmers who could potentially grow the crop, especially if a technology were available to make the crop attractive to these farmers. In this chapter we assume the more usual situation where the survey population consists of farmers already growing the crop. However, the procedures can be easily modified to include populations of farmers based on other criteria.

Because it is not possible to interview all farmers in the target group, we interview a part or a *sample* of the farmers and use the information obtained from this sample of farmers to make statements or inferences about all farmers in the population. That is, we describe cropping patterns and management practices, use of inputs, and production problems for the whole population using information from the sample. Our objective in sampling is therefore to select, at reasonable cost, a group of farmers which is roughly representative of farmers in the population. A representative sample must be selected at random—that is, where each unit in the population or subgroup of the population has an equal chance of selection. A representative sample must be of a certain minimum size in order to confidently make statements about the population as a whole. However, as the sample size increases, so do costs. Therefore, sample sizes must be kept within reasonable bounds.

The unit of interest in sampling is those members of the farm family who make decisions about technologies. This applies even in cases discussed later in this chapter where plots or fields are sampled rather than farmers. In this case the field is only used as a convenient means for identifying farmers who then become the focus of the survey.

In this chapter we describe practical sampling methods which we have found to give representative samples. These methods provide several alternatives, at least one of which should be appropriate in a given situation. The relative advantages of each method are also given to help in making decisions on which one to use.

8.1 Stratification

Stratification of the population is the process of dividing the population into relatively homogeneous subgroups called strata, and then taking separate samples from each group or strata. For example, let us assume we are surveying an area with two distinct groups of farmers with different management practices: small subsistence-oriented farmers who comprise 90 per cent of the farmers in the area, and large commercial farmers who are only 10 per cent of all farmers. If we take a random sample of 100 farmers, we expect about 90 small and 10 large farmers. (In fact there is a 45 per cent probability that we would get less than 10 large farmers). In this case we probably have more small farmers than needed to represent this group while only 10(and perhaps less) large farmers is hardly sufficient to be representative of this type of farmer. A more efficient procedure is to stratify the population into small and large farmers and choose, say, 50 small farmers and 30 large farmers,[1/] thus reducing total sample size and providing more

1/ The actual number chosen will depend on the relative variation in each farm size group. See Section 8.3.

Example 8.1: Two-stage Sampling

In a tropical maize growing area, two-stage sampling enabled considerable cost savings. Farmers in the target population had been grouped into villages based on land reform units. At the head of each village was a local official who had lists of all farmers in that village. The following steps were taken in sampling. First, a complete list of all villages in the region and the number of farmers in each was drawn up. Second, villages were stratified as far as possible by three previously defined recommendation domains—heavy vertisol soils on flat land, the same soil type but on hillsides, and lighter alluvial soils on flat land. In this case villages could only be distinguished by soil type as most villages with heavy soils included both sloping and flat land. Third, a relatively small number of villages (eleven for the first two recommendation domains combined, and four for the third) were selected randomly so that the probability of [illegible] list of [illegible] officials [illegible] farmers [illegible] asking the local officials to [illegible] a container. This gave a total sample of [illegible] 110 in the first two recommendation domains and 40 in the third (although only 130 were finally interviewed because of not-at-homes, etc). The sample size in the third recommendation domain was smaller than the others because of the relative uniformity of the domain. The two-stage procedure saved costs because (a) selected farmers were clustered into a few villages reducing travelling time, and (b) the purpose of the survey could be explained to local officials at the time of sample selection. It was also possible because lists of villages and farmers were already available.

* The procedure used was to cumulate the number of farmers in each village with village 1 with 55 farmers receiving the numbers 1-55, village 2 with 33 farmers, the numbers 56 to 88 (55 + 33 = 88), village 3 with 75 farmers the numbers 89 to 163 and so on. Random numbers were then drawn to choose villages. If the number 89 was drawn, then village 2 was chosen. In this procedure the probability of a village being chosen increases proportionally with the number of farmers in that village, but each farmer in the area has equal probability of being chosen.

information on the large farmers at little or no sacrifice of information about small farmers.

It is convenient to stratify as far as possible using the recommendation domains previously delineated—that is, groups of farmers of similar agro-climatic and socio-economic circumstances for which the same technologies can be recommended. In the case of recommendation domains based on agro-climatic characteristics such as rainfall, elevation and sometimes soils, it is usually possible to divide the region into distinct geographical areas for the purpose of sampling. However, with other agro-climatic characteristics such as sloping versus flat land, this may not be possible since these different agroclimatic environments may occur even within a single farm.

One of the most common socio-economic characteristics used in defining recommendation domains is farm size. However, stratification by farm size requires a knowledge of farm size prior to sampling and this is not always available. If recommendation domains are defined on the basis of location—usually proximity to large town(s)—there is no difficulty in dividing the area into strata for sampling purposes.

In summary, try to stratify the population by recommendation domains prior to sampling. In many cases only a partial stratification is possible. For example, with recommendation domains based on rainfall and farm size, it might only be possible to stratify by rainfall since data on farm size are not available prior to sampling.[1/]

8.2 Random Sampling Procedures

Random sampling is a selection procedure which ensures that every unit of the population or a strata of the population has an equal chance of being selected. Random sampling is best done with a table of random numbers such as those

1/ Where farmers cannot be conveniently stratified, quota sampling may be useful. A quota is set for each stratum and farmers are randomly selected, visited and asked a screening question to determine the strata to which the farmer belongs to. If the quota is already met, the interviewer proceeds to the next farmer in the sample until the quota is met for each stratum.

Recommendation Domain	Elevation	Crop	Sample Size
Valley Floor	3100-3500 m	Maize	125
East Slope	3500-3950 m	Potatoes/wheat	60
West Slope	3500-3950 m	Potatoes/barley	50
High Elevation	3950 m +	Bitter potatoes	20

In this case, sample size was [illegible] heterogeneity of each domain leading to a [illegible] sample in the valley floor. The sample size in the [illegible]

usually found in a statistics text book or through drawing numbers written on paper or cardboard squares I cm x I cm, from a container.

Simple Random Sampling: In this method every farmer in the population or in each strata (if the population is stratified) is listed and a table of random numbers is used to select the farmers to be interviewed. This is a very simple method. Its main disadvantage is that a reliable list of all farmers in a region or strata is usually not available. Lists kept for tax purposes, for example, are often incomplete.

Two-Stage Sampling: In this method a random sample of villages is taken from a list of villages in the region or in each strata and then a sample of farmers is chosen randomly from a list of farmers in each selected village (see Example 8.1). Using this procedure, it is only necessary to construct lists of farmers for the selected villages. In addition, interviewing costs are also reduced because of the geographic clustering of the farmers. Counties or townships, cooperatives, and land reform units, may also be used in the first phase of sampling.

Field Sampling: At times it may be more convenient to sample fields rather than farmers. The cultivator of the field is identified and then interviewed. Fields may be randomly sampled by several methods. Topographic maps and aerial photos of scale 1:50,000 or less are available for many areas (although often difficult to locate) and can be used for sampling. Any strata based on factors such as rainfall or location are first identified on the maps. Points on the map are then selected by randomly drawing pairs of coordinates (three digits will usually suffice). In the field each point is located and the cultivator of the field at that point then becomes the selected farmer (see Example 8.2). If detailed maps are not available then points may be randomly located on more general maps (e.g., a road map). Then in the field that point is very approximately located and a field chosen randomly from all nearby fields—for example by walking a fixed distance in a certain direction.

The main advantage of field sampling is that it avoids making lists of farmers or villages. However, because the field is the unit of sampling, larger farmers have a higher probability of being selected and weighting of data is required when summaries are made of average farmer practices in the area (see Chapter 10). Moreover these procedures may be costly to implement where travel is difficult and impractical where it is necessary to establish contact with local leaders such as village officials before interviewing a farmer. A modification of the above procedure using two-stage sampling solves some of these problems. In this method a segment (e.g., one square kilometer) is selected at random on a map using similar procedures to those above. In the field, all farmers who have fields within the segment are identified and if this number is too large, a random sample is chosen from this group of farmers. If the segment is large relative to average field size each farmer has equal probability of being chosen. Moreover, travel time is again reduced by the clustering of farmers.

8.3 Sample Size

A representative sample must not only be

random but must also be large enough to reflect all farmers in the region. Well-known statistical rules for determining sample sizes on the basis of the variability within the sample cannot be formally applied for this type of survey. Nonetheless, consideration of the variability within the target region is important in determining sample size. As a general rule we have found that 30-50 farmers for each recommendation domain will usually reflect quite well the circumstances of farmers in that recommendation domain. Where it is not possible to stratify by recommendation domain for sampling purposes, try to choose a sample size that will result in *at least* this number of farmers in each recommendation domain.

The sample size should be adjusted according to the amount of variability in the population. In an area where there is much variability within recommendation domains, for example, due to mountains and where any further disaggregation would create too many domains, the sample size should be increased. On the other hand, in an irrigated land reform area with similar size farms and agro-climatic characteristics, a smaller sample size may be in order. *Note that the sample size depends on the variability within the population and not on the size of the population.* The percentage of farmers sampled may vary substantially between regions or recommendation domains.

A list of "replacement farmers" should also be drawn up to enable substitution of farmers included in the original sample who are not available for the interview or who do not meet the sample requirements (e.g., do not grow the target crop). If a sample size of 40 is desired, a sample of 40 is drawn and then a list of say ten replacements is also drawn. If a farmer in the sample of 40 cannot be interviewed, then that farmer is replaced by the *first* farmer on the replacement list and so on.

Finally, sample size must conform to the time and cost constraints of the survey. However, the major costs of a formal survey are the *fixed* costs of developing the questionnaire, training enumerators and establishing a suitable sampling method . The marginal cost of including additional farmers in the sample is relatively low. For this reason we favor increasing sample size when there is doubt about the adequacy of the sample size for representing some variables.

8.4 Non-Response

It is common to find farmers away from home at the time scheduled for the interview. If these farmers are omitted from the survey, the results will be biased toward the type of farmers who are at home most of the time. Those who are often gone from home could be those who have part-time work off the farm; those who are community leaders; those who leave frequently for machinery repairs or purchase of inputs; or those who idle in village coffee houses or taverns. It is clearly worth some special effort to ensure that these types of farmers have the same probability of being in the sample as do the stay-at-homes.

In practically no case should a not-at-home be dropped from the sample on the basis of one attempted interview. In few cases would more than two return calls be cost effective. The choice will depend upon the cost of return calls and the number of *other* not-at-homes encountered in the sample. Occasionally non-responses will be due to the farmer's refusal to cooperate. In our experience this is not common in a well-managed survey. Procedures to ensure farmers' cooperation are discussed in the next Chapter.

SELECTED FURTHER READINGS

CHAPTER 8

1. Raj, Des, *The Design of Sample Surveys,* Mc Graw Hill, New York, 1972.
   (Chapter 1-9 provide detailed discussion of application of sampling theory to survey design.)

2. Kearl, B. (ed.), *Field Data collection in the Social Sciences,* Agricultural Development Council, New York, 1976.
   (Chapter 3 reviews various sampling approaches used in micro-level surveys in Africa.)

chapter 9 implementing the formal survey

With a questionnaire developed and a sample drawn, the formal survey is ready for implementation. Successful implementation requires a team of capable interviewers, the farmers' cooperation, correct completion of the questionnaire and close supervision by the researchers of these activities. In this chapter we shall look at each of these in turn and finish with an example of the implementation of a successful survey.

9.1 The Interviewer

The interviewer is the middleman between the researchers and the farmers. The quality of the interviewer is one of the most important factors in conducting a successful survey.

Number of Interviewers: Even with our recommendation that the questionnaire be designed to be completed in less than 90 minutes, it is our experience that interviewers will only average about one to two interviews per day. The remaining time is spent locating farmers, waiting for public transportation, and conducting "return visits." In a typical survey of say 120-150 farmers (e.g. 40-50 farmers in each of three recommendation domains) we would need about three interviewers to complete the survey in a month. The survey could be completed more quickly by using more interviewers over a shorter period of time, say 12 enumerators for a period of a week. However, the quality of the data will usually be lower because each interviewer has less opportunity to develop his skills through on-the-job training and will also receive less intensive supervision.

Selection of Interviewers: The researcher should personally recruit the interviewers. Four characteristics are important in selecting interviewers: a) motivation to work hard and honestly, b) ability to fill the questionnaire correctly (usually determined by some minimum level of schooling and intelligence), c) ability to communicate with the farmers in the local language, and d) knowledge of local agriculture and respect for farmers and rural people. Some of these characteristics, such as language ability, ability to complete the questionnaire, and knowledge of local agriculture, can be evaluated in recruitment interviews and in training; other characteristics such as motivation and honesty must depend on personal assessments by trusted acquaintances.

In the ideal situation the research program employs its own research assistants recruited on the basis of the above characteristics. These research assistants are then available not only for survey work but also for other activities of the research program, particularly work on on-farm experiments and demonstrations.

Where such research staff is not available, the best choice is usually to hire, on a temporary basis for the survey, sons of local farmers who have completed at least a primary school education and who are literate. During school vacations, high school students (again farmers' sons) or local school teachers can also be employed. Although university students have been widely used in surveys, they are unsuitable if they lack respect for farmers and rural customs.

Training the Interviewers: The training period for this sort of survey will depend on the type of interviewer. It will vary from two days for research staff already familiar with survey work to five days or more for temporary staff. The training period should include the following:

a) The purposes of the survey should be fully explained including an explanation of how the

data will be used in planning on-farm experiments and experiment station research.

b) The questionnaire should be explained question by question. (Many explanatory notes should also appear on the questionnaire.) The sampling procedure should be explained and local terminology and units of measure discussed.

c) The plan for field operations should be explained, including instructions on the interviewer's responsibilities for screening respondents and action to be taken for nonrespondents.

d) Interviewing techniques should be described and practiced among each other.

e) If the interviewers are unfamiliar with the area, they should be taken on a tour and given background information on the agriculture, social structures and government development activities in the area and introduced to relevant local authorities.

f) Field interviews should be conducted by the interviewers both in the presence of one of the researchers and alone. The respondents should not be part of the sample, nor should the data be used. These interviews may be made a part of the tour of the area, if one is conducted.

The effectiveness of the training and subsequent field work can be greatly increased by developing an interviewer's manual. This manual should be comprehensive and discuss all the points covered in training, i.e. purpose of the survey, explanation of *each* question, logistics and interviewing techniques. Also the manual should be a ready reference of common diseases and pests, chemicals and varieties available in the area. The interviewer should be required to have this manual with him at all times.

The training period is a good time to "weed out" undesirable interviewers. In fact, it is best to hire interviewers on the condition that they successfully complete the training course. In this case allow for drop-outs at the time of recruitment.

9.2 Gaining Farmers' Cooperation

Farmers' cooperation is essential to the success of the survey. This cooperation is gained at two levels: a) through support of local leaders, particularly in societies in which these leaders enjoy considerable respect, and b) by correctly introducing the survey to the farmer. The support of local leaders is best obtained during the exploratory survey through personal visits by the researchers to explain the purpose of the work. These local leaders can then be asked to help explain the work to the farmers in the sample. Also, where two-stage sampling is used and selected farmers are clustered into villages, it is often helpful to have group meetings with the farmers in each chosen village for the purpose of explaining survey objectives and enlisting their help.

To obtain the cooperation of individual farmers, the interviewer should introduce himself, explain for whom he is working, and explain fully the need to have information about farmers' production practices and problems to help direct research work. While the potential benefits of the information to farmers as a whole may be mentioned, each farmer should understand that he will receive no special consideration as a result of participation in the survey. The use of the information to guide experiments on farmers' fields in the area should be explained. If on-farm experiments are already planted in the area, farmers may be invited to visit the closest experimental site. Finally, the farmer should be told that he or she was selected on a lottery basis and that all information provided will be kept confidential. In two-stage sampling it is sometimes helpful to have village leaders select the farmers by drawing numbers from a container where numbers correspond to names on a list of farmers. The random method of selection is then made obvious to the farmers.

It is best to interview the farmer when and where it is convenient for him. For this reason, the survey should be planned for implementation in a relatively slack time in the agricultural calender. Moreover, if the farmers are to be interviewed at home, early morning and late afternoon usually will be less disruptive to their work schedule. However, farmers often perceive more interest if the interviewer is willing to go to the field for the interview. This also provides an opportunity for direct observation of the crop in the field. If the farmer is very busy, offer to help him for a while before beginning the interview. Above all, treat the farmer with respect.

When these steps are taken, it has been our experience that farmers are very willing to cooperate with this type of survey. Gifts or remunerations are not necessary except according to local customs. Problems of cooperation usually arise when the researchers do not inform local leaders, do not explain the purposes of the survey to the farmer or do not treat the farmer with respect.

9.3 The Interview

In general, interviews should be conducted with the primary decision maker for the target

Example 9.1: Survey Implementation

In one successful survey a sample of 130 maize farmers clustered in eight villages was interviewed in an area of strong traditional village leadership. At the beginning of the research work letters were sent from the head of the agricultural research institute to the local government official in the area presenting the researchers, explaining the purposes of the survey, and asking him to advise the village leader in each *selected* village about the work. (A two-stage sampling procedure was used.) During the exploratory survey the government official was personally visited by the researchers and asked to accompany them on a tour of the area and present the researchers to the village officials. The purposes of the survey were explained personally to each village leader and if it was a Friday when the farmers (who were largely Moslem) were in the village, a meeting was also held with farmers.

Meanwhile four interviewers with two substitutes were recruited by informal contacts. These interviewers were 18-25 year-old sons of local small farmers, had completed primary schooling and had been recommended to the researchers for their personal characteristics (e.g., enthusiasm, intelligence, agreeable personality). All four interviewers successfully completed a five-day training course and the two substitutes were not needed. This training course consisted of a full explanation of the purpose of the survey, the role and character of the sponsoring agency, the way in which collected data would be used, and methods of gaining a respondent's cooperation. They were then given a question-by-question explanation of the questionnaire, with possible ambiguities pointed out and clarified. Subsequently, they conducted mock interviews with each other; the researcher and other enumerators criticized each performance. Finally, they were assigned interviews with local farmers, the results of which were carefully scrutinized. These trial interviews provided further opportunities for pre-testing the questionnaire, and several changes suggested by farmers or interviewers were incorporated at the final hour.

During the survey the interviewers were introduced to the village leader by the researchers and a list of randomly selected farmers was given to the leader who was then asked to advise each farmer of the coming survey. At this time the survey was administered to the village leader to demonstrate its nature and ensure cooperation of other farmers. (The information was not used in later analysis.) Because the survey was timed at a slack period just before harvest, many farmers were in the village. Those who worked in fields at a reasonable distance from the village were often interviewed in the field. The village leader was asked to provide accommodation for the interviewers during the survey in that village. Interviewers were given an adequate overnight allowance for food and lodging and to provide an incentive to remain with the survey until its completion.

The supervisor divided his time between advance work in the next village, collecting and editing previous questionnaires on a daily basis, and surprise visits to interviewers in the field. He also informally revisited some farmers to check on the quality of the information obtained by one interviewer in whom he did not have full confidence.

The survey was completed by four interviewers in four weeks. Only one of the farmers refused to cooperate after the purposes of the survey were explained. Researchers were pleased with the high quality of data obtained, which they attributed to the training, personality and local knowledge of the interviewers and the constant supervision by one of the senior researchers.

crop. In some cases this may be the women of the household, in which case female interviewers may be more suitable. In any case, women may play an important role in crop production and be responsible for decisions concerning certain cultural practices (e.g. weeding) and food processing and consumption. In this case it may be better to ask questions related to these activities directly to the women, provided it is done with the consent of the household head.

The interviewing should be as relaxed and informal as possible. The farmer is most comfortable sitting down in his house or under the shade of a tree in his field without the presence of other people. The interviewer can help by conducting the interview as a conversation. He should know the questionnaire so well that he memorizes individual questions and does not laboriously read them. The farmer is encouraged to talk about certain topics with gentle direction from the interviewer. Additional information or unusual information may be recorded in space provided on the questionnaire.

The interviewer should ensure that the

farmer understands the question but should not inject his own opinion. He must be alert for responses which are irrelevant, vague, improbable, or inconsistent with previous responses. When such responses are noted, the interviewer should *probe* further by asking related questions which will help to clarify such responses. The interviewer must be careful that these probes do not *suggest* answers, as the respondent may acquiesce to the suggestion as being the easiest way to solve the problem.

Before terminating the interview, the questionnaire should be reviewed to ensure that all information is complete. Interviewers should record responses for all questions. If a question is not applicable (e.g., a question about time of bean planting for farmers who don't plant beans) then NA should be inserted. If the farmer doesn't wish or cannot respond to a question, then NR for non-response may be recorded on the questionnaire.

9.4 Supervision

Experience shows that constant and effective supervision is critical to the success of a survey. The researcher(s) must be in the area during the period of the survey acting as field supervisor throughout. At the beginning of the survey, he or she should, to the extent possible, collect and *field edit* the questionnaires on a daily basis. Field editing consists of checking through the questionnaire for legibility, completeness, and consistency. Regular and frequent field editing allows the supervisor to discuss problems with the interviewer while the interview is fresh in his mind, and also provides motivation for the interviewer since he knows his work will be quickly and thoroughly examined.

In addition, the supervisor should spot check the work in the field to determine that interviewers are conducting interviews when and where scheduled. It is useful to reinterview a few farmers on an informal basis to check that the interviewer is doing his work correctly. Finally, the researcher learns much from this intensive supervision which later helps to interpret the data.

As the survey proceeds with the interviewers gaining more confidence and the researchers gaining confidence in the interviewers' work, the level of supervision can be relaxed. In particular, we have often found that for surveys extending over two weeks, the best of the interviewers can be chosen to finish the work with little supervision.

SELECTED FURTHER READINGS

CHAPTER 9

1. Kearl, B., *Field Data Collection in the Social Sciences,* ADC, New York, 1976.
   (Chapters 7-10 contain many useful experiences in survey implementation.)

2. Bernsten, R., *Design and Management of Survey Research,* Draft Paper, International Rice Research Institute, 1979.
   (Chapters 8-10 provide guides for survey implementation.)

3. Spencer Dunstan S.C., "Micro-level Farm Management and Production Economics Research Among Traditional African Farmers: Lessons from Sierra Leone," Africa Rural Employment Study No. 3, Michigan State University, 1972.
   (An overview of implementation procedures used in farm level surveys in Sierra Leone).

PART III

using a knowledge of farmer circumstances to plan crop research

Once the formal survey is completed, the data must be quickly analyzed so that the information on farmer circumstances can be immediately incorporated into decisions on crop research. This analysis is best undertaken according to the objectives listed in Chapter 2 for collecting information about farmer circumstances. First, boundaries of recommendation domains are checked and further refined if necessary. Second, the characteristics of farmers, their management practices and their fields must be quantitatively described to help guide the choice of representative sites and practices for on-farm experiments. Finally, there is the diagnostic objective to verify and test hypotheses formulated in the exploratory survey with respect to a) understanding current farmer practices and b) identifying relevant problems of farmers and prescreening technological components for inclusion in on-farm experiments. The survey data are also screened to identify problems and constraints of farmers that should guide research on experiment stations, such as the development of new varieties, and to identify the implications for policies relating to credit and input distribution and marketing, which support the introduction of new technologies.

Chapter 10 focuses on methods for analyzing the survey data to meet the descriptive objectives and to test hypotheses on farmers' practices and problems. Chapter 11 presents a set of procedures for prescreening technological components for on-farm experiments and establishing priorities for varietal development. Finally, some examples of the application of these procedures are given in Chapter 12.

chapter 10 analyzing the survey data

In this chapter we show how information can be extracted from the survey to meet each of the survey objectives. In addition, we describe methods for efficiently assembling this information.

10.1 Refining Recommendation Domains

Recall that recommendation domains have been defined in the assembly of background data and in the exploratory survey. A first step in the data analysis is to check that variation in farmers' practices do correspond with these domains. On the basis of this checking it might be necessary to combine recommendation domains, create new ones or simply adjust boundaries. This is done by observing whether variation in current farming systems and crop management practices in the region are related to those agro-climatic and economic circumstances hypothesized from the exploratory survey to be important in determining research priorities and recommendations. Practices to consider are: importance of various crops and varieties, intercropping practices, rotations, planting method and dates, tillage techniques, yields and crop disposal. This can be done by arranging data for farmers in the sample according to each circumstance hypothesized to be important and then looking for a tendency for some of these practices to be related with that factor. For example, if rainfall is hypothesized to be important, data for farmers is arranged according to approximate rainfall gradients to observe any changes in farming systems and practices. If farm size is hypothesized to affect management practices, farmers should be

[illegible] and seeding rate. However, it was not possible to determine at what farm size these practices became common. By arranging data from the formal survey in order of increasing farm size, it was decided to include farmers with over 20 ha as a separate group [illegible] different [illegible] machinery.

arranged in order of increasing farm size to look at variation in variables such as crops grown, crop rotations, tillage practices, planting method, intercropping or production problems with increasing farm size. This procedure is illustrated in Example 10.1.

This analysis will usually allow more precise drawing of boundaries of recommendation domains.

10.2 Assembling Information on Farmers' Practices:

A description of farmers and their practices in each recommendation domain is used to help select sites for on-farm research that are representative in terms of soils, tillage techniques, rotations, topography, etc., and then to provide representative practices in terms of time and method of planting, weeding, etc. for conducting experiments on these sites. Also it is useful to assemble some background price, labor input and cost information *relevant* to prescreening technologies. These data are *specific* to those technologies which were hypothesized in the exploratory survey

Example 10.2 Tabulation of Farmer Practices by Recommendation Domain—Tropical Maize

The table shows an example of assembling descriptive statistics by recommendation domains in a tropical maize producing area. Initially three recommendation domains were distinguished a) large-scale farmers, b) farmers of the land reform program growing maize on flat land and c) farmers of the land reform program growing maize on sloped land. The research program decided to focus on the latter two groups where potential pay-offs in terms of production and income equality were greater. The basic difference in practices of farmers is seen to be in land preparation where farmers with flat land generally use tractors while farmers on steep land use hoes or simply slash with a cutlass. Other practices are essentially the same for both recommendation domains. The base practices for on-farm experiments would then consist of tractor ploughing and harrowing on flat land and hoeing on steep land, the local variety planted at a density of 35,000 plants/ha, weeded by hand with the first weeding about four weeks after planting and use of insecticide but no fertilizer.

General Farm Data	Recommendation Domain: Flat Land	Recommendation Domain: Steep Land
Average Farm Size (ha)	11.1	10.2
Area in Maize in August (ha)	4.6	2.6
Area in Tree Crops (ha)	3.5	2.7
Annual Cropping Pattern in Selected Field		
Per cent Maize-Maize	31	37
Per cent Maize-Maize-Beans	33	33
Per cent Maize-Squash-Maize	12	10
Per cent Other Systems	24	20
Land Preparation		
Per cent Plough-Harrow (with tractor)	38	0
Per cent Harrow Only (with tractor)	24	0
Per cent Hand Hoe	34	68
Per cent Chop Only or Chop and Burn	3	27
Planting		
Per cent Plant "Improved" Variety	18	3
Distance Between Rows (cm)	103	102
Distance Between Hills (cm)	92	94
Average Seeds per Hill	3.7	3.9
Per cent Replant	26	35
Weeding		
Per cent Weed with Horse or Tractor	15	3
Per cent Weed with Hoe	85	97
Per cent Weed Twice	83	80
Average Time of First Weeding (Weeks after Planting)	4.5	3.8
Other Inputs		
Per cent Apply Insecticides	86	82
Per cent Use Fertilizer	2	0
Production		
Average Yield (Ton/Ha)	1.2	1.1
Per cent Maize Sold	63	56

as having potential to address key farmer problems (e.g., labor data on weeding is needed to prescreen weed control technologies).

The information in table 3 shows the type of information that is needed here to describe practices of farmers *in each recommendation domain.* This tabulation is relatively simple once recommendation domains have been established. Descriptive statistics are assembled for each type of variable. These may be either frequencies or means. Variables which are not quantified must be presented as frequencies (e.g., type of variety, power source for land preparation etc). Histograms are a convenient way to present frequencies. Variables which are quantified (e.g., seeding rate, area, labor inputs, yield) may be presented as means as well as frequencies to show the variability within the sample. For many inputs it is useful to complete both statistics: (a) the frequency (percentage) of farmers using the input, and (b) the average rate of use of the input *for those farmers who use it.*

Table 3 shows that each type of tabulation is performed to meet certain objectives of the survey. For example, to establish representative practices for the on-farm experiments tabulations are needed on intercropping, density, all field operations and use of specific inputs. This information should be quite specific. For example, timing of field operations or input application is important in representing farmers' practices in on-farm experiments. Sample tabulation of survey data on farmers' practices are shown in Examples 10.2 and 10.3.

Table 3. Information For a Descriptive Tabulation of Farmer Circumstances in Each Recommendation Domain and Uses of the Information

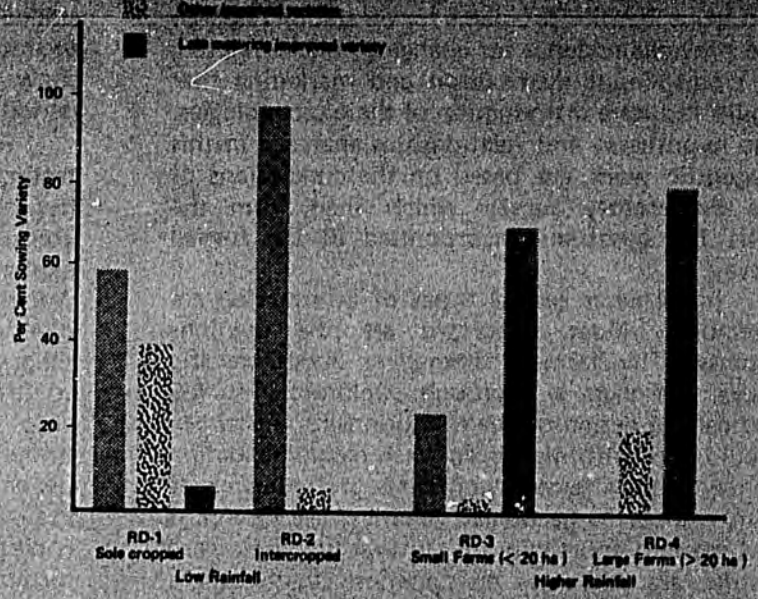
Type of Information	Details of Tabulations[a]	Use of Information
General farmer data		
Farm size		
Land tenure		
Crops grown		
Specific field data		
Area		
Soil		
Topography		
Intercropping		
Density and spacing		
Basic operations		
Clearing		
Land		
Land preparation		
Planting		
Irrigation		
Weeding		
Harvesting		
Inputs		
Seed		
Fertilizer		
Insecticide		
Herbicide		
Crop production/Output		
Yield of crops or [illegible]		
Crop [illegible]		
Value [illegible]		
Use of [illegible]		
Other data		
[illegible]		
[illegible]		
[illegible]		
[illegible]		

a/ Averages are means of the variables. Per cent x type are percentages of farmers with specific characteristics such as land owner, share cropper, renter in the case of land tenancy or maize, maize-beans, maize-sorghum, maize-sorghum-beans in the case of intercropping.

Example 16.2: Transition of Farmers [illegible]

The table below shows the results of a survey of barley producers where farmers have been divided into four recommendation domains based on three factors: rainfall, intercropping with a perennial (restricting machinery use), and farm size. This table shows basic differences between land preparation and seeding practices and inputs by recommendation domain. Use of improved varieties, fertilizer and herbicides is common in the higher rainfall areas particularly for large farmers. Use of tractors for land preparation is minimal in the second recommendation domain.

From the same survey a histogram showing frequency of use of varieties has been constructed in the figure on the right. Again in recommendation domain three, farmers use later varieties because of their more favorable climatic circumstances.



Variable	Recommendation Domain: Low Rainfall		Higher Rainfall	
	1 Sole Cropped	2 Inter-cropped	3 Small <20 ha	4 Large >20 ha
General Farm Data				
Average area barley (ha)	4.6	4.7	3.4	57.1
Per cent flat land	95	44	12	50
Per cent who prepared land with tractor	81	19	71	100
Per cent area in barley	89	89	76	91
Basic Operations				
Per cent ploughing before planting	100	56	100	100
Per cent plough after harvest	49	2	18	60
Per cent harrow one or more times	100	41	50	100
Sowing–per cent broadcast	88	100	100	20
–per cent drill	12	0	0	80
Covering broadcast seed–per cent with harrow	100	25	79	100
–per cent with plough	0	75	21	0
Inputs				
Variety–per cent using improved variety	46	2	75	100
Fertilizer–per cent apply nitrogen	4	2	40	80
Herbicide–per cent use 2-4D	0	2	32	100
Production and Disposal				
Yield (tons/ha.)	.91	.60	1.00	2.30
Per cent sold	29	52	70	100

10.3 Diagnostic Analysis of Farmer Circumstances

The next stage of the data analysis is to verify particular aspects of farmer circumstances that were hypothesized to influence current practices and that might guide the choice of technological components and their levels for on-farm experimentation. This diagnostic work also helps identify problems for on-station research and provides evidence for changing policies relating to credit, input distribution and marketing that would facilitate introduction of these technologies. The hypotheses and relationships analyzed in this diagnostic work are based on the conclusions of the exploratory survey which then form the basis for questions incorporated in the formal survey.

In all cases several types of information are assembled. Most important are the opinions expressed by farmers themselves about specific issues. Through a thorough exploratory survey and careful design of the questionnaire, the survey should elicit information for each recommendation domain about farmers' opinions and preferences with respect to particular varieties, use of inputs and method and timing of cultural practices. Also helpful are responses on common circumstances leading to crop losses, e.g., drought (at particular times in the crop cycle), specific insects and diseases, and difficulties in obtaining inputs or marketing produce (see Example 10.4). If the survey includes field observations, tabulation of data on the incidence of problems in farmers' field is also valuable.

Data on the farming system—for example periods of labor bottlenecks, food preferences, rotations—give the researchers a better understanding of the farming system into which new technologies must be introduced. Example 10.5 shows the results of a question aimed at determining periods of peak labor demand.

Finally, cross-tabulations are important in testing hypotheses about farmers' behavior. These hypotheses will have been formulated over the course of the survey work and particularly in the exploratory survey. For example, if a considerable variation in time of planting is observed with likely consequences for yield, we might cross-tabulate time of planting with factors hypothesized to affect time of planting such as the previous crop in the field, method of land preparation, ownership of equipment, or period of food scarcity (leading to earlier planting). Or chemical fertilizer use might be hypothesized to be related to type of rotation followed, type of land, use of organic fertilizers or availability of credit. Choice of variety might depend on the end use of the crop, local soil type or intercropping practices. The hypothesis on circumstances leading to the use of a given practice

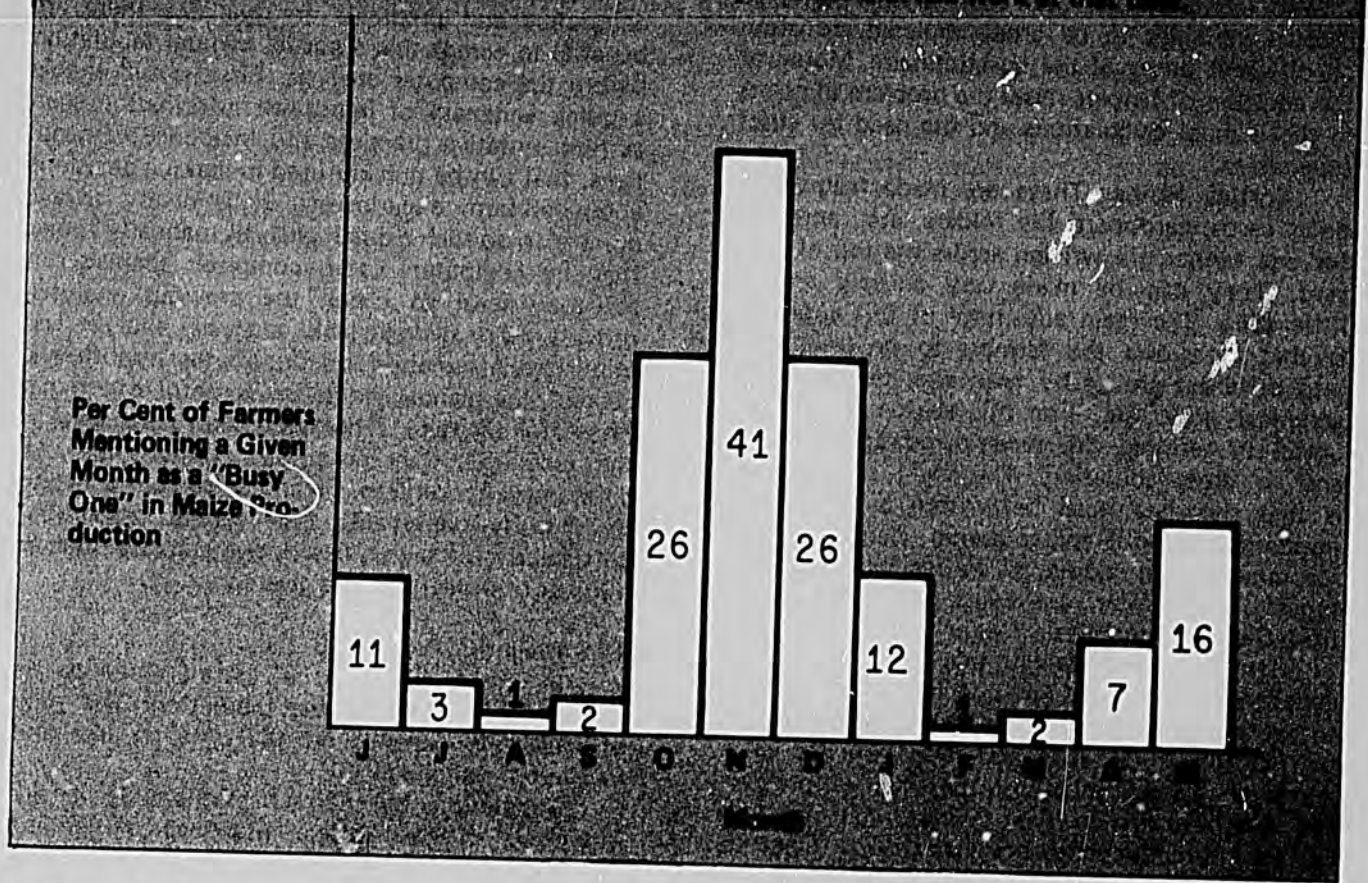
Example 10.4 Tabulation of the Incidence of Climatic Risk Expressed by Farmers in a T

In one survey farmers were asked about the incidence of certain climatic risks in various crops. In the table below, it is clear that rainfall, both too much and too little, is dominant among farmers' risks. The [illegible] care in choosing [illegible] For example, [illegible] tance to ear rot.

Type of Climatic Risk	Per Cent of Farmers Reporting Problem in Past Three Seasons
Heavy late rains—maize cobs rot	73
Rains finish early—late planted beans fail	65
Rains finish early—poor grain filling of maize	60
Heavy early rains—poor germination of finger millet	60
Heavy early rains—poor germination of maize because of waterlogging	42

Example 10.5: Histogram of Selected Labor Questions

Farmers' response to a question about the busiest months of the year is shown in the figure below. Clearly October-December is a peak work period and January and March are [illegible] reduce their work. A [illegible] reject those that hold work at that time.



will arise from the exploratory survey. Sample cross-tabulations from one survey are shown in Example 10.6.

Obviously the range of cross-tabulation is infinite. The important point is that the specific tabulation chosen should reflect hypotheses of the researchers about the use of a given practice. Statistical tests such as the Chi-squared test may be employed in this analysis to provide a degree of confidence in the observed associations. Also at this stage it is often helpful, when testing hypotheses relevant to all recommendation domains, to combine data across recommendation domains to ensure a large enough sample.

10.4 Methods for Tabulating Information

Several methods are available to tabulate survey information and the method used will depend on the size of the sample and the time and resources available for the task. *All* methods require that *all* questionnaires be edited to convert quantities to standard units, clarify inconsistencies and discard any questionnaires where inconsistencies are too large or non-response is too high. It is also desirable (again regardless of method used) to list out data for each important variable on a sheet of paper to help find errors and note the range of response.

Tabulating Directly From the Questionnaire: In this method the questionnaires are arranged by recommendation domains and opened to a given page. Data are simply taken by flipping through the questionnaire and counting the frequency of farmers using a given practice or averaging with a pocket calculator the amounts of a given variable (e.g., seed rate) over all the farmers in each domain. When all relevant variables on that page are tabulated, all questionnaires are opened to a new page and the process continued.

The advantage of this approach is that it

can be done immediately with only a pocket calculator. The main disadvantage is that for larger sample sizes, say over a hundred, it is time consuming unless clerical helpers are available. If cross-tabulation is to be used extensively, it is also cumbersome even for smaller samples because variables to be cross-tabulated are often on different pages of the questionnaire. Moreover the addition of helpers raises the problem of errors in the manual calculations and the need for strict supervision.

Sorting Strips: These are made from computer cards, cardboard file folders, etc., and data for one farmer are written across the top of each card. They can be made very cheaply and in little time. The main advantage of this approach is that it allows the farmers to be re-ordered into different groups by farm size, tenancy, geographical area, etc. For this reason it is most useful in refining the recommendation domains and in cross-tabulation. The main disadvantage is that the data must be written out from the questionnaire prior to tabulation. Generally once recommendation domains are established most types of tabulation are easier to make directly from the questionnaires.

Use of Computer: In this case all data are coded onto computer key-punch forms according to prearranged codes (e.g., planting by hand = 1, by machine = 2, etc.) and then punched onto computer cards. It is also possible to precode the questionnaire in such a way that data are punched directly on to computer cards. Once on computer cards, standard statistical packages or specially written programs will quickly tabulate the data. It is beyond the scope of this manual to describe computer processing procedures but supplements to this manual describe how to code the information and provide a simple computer program easily adapted to most computers for doing simple tabular analysis.[1/]

The main advantage of the computer is that once the coding is done the tabulation can be done very quickly even for very large samples, given the availability of a suitable program and computer. Moreover, it enables statistical tests of differences between groups of farmers to be easily performed. The main disadvantages are: (a) the tendency to overlook errors or relationships in the data that would be revealed in manual analysis, and (b) the cost in time and money to translate the data onto cards and to become familiar with a program suitable for doing the analysis. In general this latter disadvantage is outweighed if the sample is over 100 farmers and key punching, programming time and computer time are *readily* available.

Even where the data set is large enough and computers and programs are available there are benefits to completing a partial manual tabulation before the computer analysis. First, it will enable a quick summary of important information such as representative practices and incidence of problems, that can be quickly used in making decisions about on-farm experiments. It is nearly always quicker to do such a quick analysis manually rather than by computer. Later, computer analysis can still be useful to check the previous analysis, provide more disaggregated analysis, analyze less important information and formally test hypotheses. Second, the manual tabulation is useful in getting a "feel" for the data. If the researchers participate in the tabulation they note new relationships and define new hypotheses. Finally, a computer listing of data is convenient for manual tabulation, particularly for simple descriptive statistics such as number of farmers using a given practice.

10.5 Weighting Procedures

In many cases not all farmers should be given equal weight in the tabulation. The type of weighting depends on the type of data and method of sampling.

Tabulation by Farmer: Generally we are interested in the average practices of farmers in a given recommendation domain. If the sampling procedure employs simple random sampling of farmers, then simple averaging over the sampled farmers is the appropriate method. However, where sampling is by field, then, as we have noted, common sampling methods lead to a higher probability of choosing larger farmers. For this reason, when averages per farmer are required, the smaller farmers must be given greater weight and larger farmers a smaller weight.

This adjustment is best made by grouping farmers into farm size groups of approximately equal numbers for the purpose of weighting. If we have groups, then the proportion of farmers in each group, p_i, in the population is given by

$$p_i = (n_i/x_i^*)/[\sum_{j=1}^{g} (n_j/x_j^*)]$$

1/ CIMMYT Economics, "Use of Computers to Analyze Farm Survey Data," and "A Users Guide to TABSM–A FORTAN Program to Analyze Farm Survey Data."

[illegible]

[illegible] before the onset of rains in November in [illegible] areas. Later the labor constraint of the November and December period and the reduced probability of waterlogging after the initial heavy rains were [illegible]

[illegible] respondents for their [illegible] preference for each grain among [illegible]

Table A

Planting time	Seedbed Types: Mounded	Ridged	Flat
	Per Cent Occurrence		
Before November	81	6	13
Early November	26	48	26
Late November	4	61	35
Early December	8	12	80
Late December	-	24	76
January	11	33	56

Table B

Age of Respondent (years)	Per Cent Who Prefer: Millet	Maize
Under 30	50	50
31-50	50	50
Over 50	68	32

where n_i is the number of farmers in group i, and x_i^* is the simple average farm size for group i. Then for calculating $\bar{y}$, say the percentage of farmers using fertilizer in the population, we simply weight the percentage of farmers using fertilizer in each group y_i^* by p_i. That is,

$$\bar{y} = \sum_{i=1}^{g} p_i y_i^*.$$

Example 10.7 shows the weighting procedure used in one area where field sampling was used.

Tabulation by Area: There are also many variables that should be expressed on an area basis, e.g. yields, fertilizer rates and labor inputs/ha so that larger farmers are weighted more heavily to provide representative statistics of the region. For example, in a random sample of farmers, average yields should be computed *not* by averaging yields of each farmer *but* by averaging *total* production (yield x area) of each farmer and then dividing by the average crop area over all farmers. The resulting yield will be more representative of the region since it gives greater weight to larger farmers which grow relatively more of the crop. Likewise, fertilizer/ha and labor/ha should be computed by averaging total fertilizer and labor use and then dividing by average hectarage.

[illegible]

Group	Average Farm Size in Group (ha)	Number of Farmers	Number Using Fertilizer in each Group
0–1.9 ha	1.3	16	2
2.0–6.9 ha	4.7	19	6
7 ha and over	18.0	14	12

Because of the sampling procedure, farmers are included in the sample in probability proportional to farm size, and the weighting procedure [illegible]

[illegible]

fertilizer in the [illegible] $+ (4 \times \frac{12}{14}) = 20$ per cent although fertilizer is applied to $(2 + 6 + 12)/(16 + 19 + 14) \times 100 = 6$ per cent of the area.

When field sampling is used, however, larger farmers are already represented in the sample in proportion to their area. In this case *simple* averages of farmers' yields, fertilizer/ha, etc., are appropriate.

Weighting where Pre-Stratification was used: If pre-stratification was used and the researcher wishes to compute averages over groups for a region, then the groups should be weighted by the proportion of farmers in the population in that group. For example, if a region with 75 per cent dryland farmers and 25 per cent irrigated farmers was pre-stratified into dryland and irrigated farmers and equal sample sizes are taken of each type of farmer, then to compute a regional average per farmer, dryland farmers should receive a .75 weight and irrigated farmers a weight of .25.

In general, however, we are more interested in representing average practices for each homogeneous group or recommendation domain than in calculating regional statistics.

SELECTED FURTHER READINGS

CHAPTER 10

1. Bernsten R., *Design and Management of Survey Research,* Draft Paper, International Rice Research Institute, 1979.
   (Discusses various methods for data analysis and also describes in detail the use of SPSS.)

2. CIMMYT, "The Use of Computers to Analyze Farm Survey Data," 1980; and "A Users Guide to FASAP—A FORTRAN Program for Analysis of Farm Survey Data."
   (Describe coding procedures and data analysis as well as a small FORTRAN Program which can be readily adapted to small or large computers.)

chapter 11 prescreening potential technological components

The circumstances of most farmers are such that they adopt technologies in small pieces, usually one or two components at a time. They do this because of (a) scarcity of capital, (b) inability to withstand large risks and (c) a learning-by-doing approach. A research program should therefore initially aim to develop two or three *best-bet* technological components which have relatively high pay-offs when added to the *farmers'* technology. This strategy also benefits research programs with limited resources which cannot afford to investigate all possible components.

There are a number of steps in identifying best-bet technological components. These are: (a) identifying for the target crop, key factors limiting farmers' production and income, (b) identifying available technological components by which those constraints may be overcome, (c) listing all changes to the farmer that will result by introducing these technological components, (d) computing rough costs and benefits to the farmer of the changes, and (e) matching the changes against the relevant circumstances of the farmer. This prescreening process, involving both the agronomist and agricultural economist, is a systematic way of reducing the infinite variety of alternative technological components down to a few best-bet components for experimentation.

Research priorities, of course, may be specific to a given recommendation domain. However, many research priorities will be general over all recommendation domains, given a relatively homogeneous target region. In fact it is even possible that the same experimental program may be implemented over the whole region. For example, if a region has two recommendation domains based on two distinct soil types, the same research program might be implemented although quite different fertilizer recommendations might emerge for each soil type, hence justifying separate recommendation domains. Generally we suggest working in a relatively homogeneous target region thinking about research priorities for that target region as a whole, and then making appropriate adjustments as necessary for the specific problems and circumstances of farmers in each recommendation domain.

11.1 Limiting Factors

As we explained in Chapter 3, we use limiting factors as short-hand to refer to those factors relating to the crop of interest which currently limit farmers' incomes. These might be factors which limit yield, reduce quality or increase costs for the target crop. Also because most small farmers store a large proportion of their grain, storage losses may be an important limitation. Or they may be factors, such as a late-maturing variety, which prevent planting of a second crop immediately after harvest of the target crop. At this stage we are mainly interested in agronomic factors such as weeds or insects, although we do need to know how these factors are modified by farmers' practices.

The process of identifying limiting factors was an integral part of the exploratory and formal survey. Agronomic observations in farmers' fields with respect to weeds, pests and diseases are an essential starting point in recognizing these factors. These, however, need to be supplemented by informal and formal interviews with farmers about their own perceptions and opinions of these factors.

In noting these factors it is important to be specific. For example, if it is an insect problem, what type of insect is it? What parts of the plant

does it damage and when and in what years is it most frequent? It is also useful to try to establish what increase in production might be possible by overcoming this constraint, as this helps rank various factors.

In addition to identifying limiting factors it is important to try to understand how farmers react to these factors before proposing solutions. Here, hypotheses formulated about why farmers use certain practices (see Chapter 3) will be particularly useful. If there is a problem of timeliness of weeding, is this because of natural factors (e.g., too little or too much rain) or economic factors (e.g., shortage of family labor or cash to hire labor). Do certain problems (e.g., diseases) relate to the type of rotation or time of planting of the crop? If so, why do farmers follow these practices?

11.2 Alternative Solutions to Limiting Factors

For each limiting factor, there is often a solution and in many cases more than one. For example, soil fertility problems can be alleviated through rotations, land preparation practices, or fertilizers. A weed control problem might be approached through more efficient methods for removal of weeds (e.g., more efficient cultivation techniques or herbicides) or through cultural practices which prevent weed growth (e.g., land preparation or plant density) or through changes in technologies in other crops which free labor for weeding.

The researchers identify solutions to problems based on the expertise of agronomist, farmers and other specialists. In many cases some innovative farmers in the area will have made cheap and effective innovations which control problems or exploit new potentials. The exploratory survey and formal survey should seek out such innovations. In other cases the researchers might wish to call upon specialized expertise to propose solutions to specific problems.

In seeking solutions to problems it usually should be assumed that most farmers are currently using their resources quite efficiently and therefore solutions must incorporate new components. Thus, in areas where farmers have considerable experience growing maize or wheat, experiments on density, plant spacing and planting date will not

Example 11.1: Listing Changes Resulting from Herbicide Use

Weeds in one tropical maize area were identified as a problem arising out of farmers' inability to conduct the first weeding early in the crop season. Wet weather and labor shortages were identified as reasons for this weeding practice. A pre-emergence herbicide was becoming available which promised to overcome this weeding problem. The changes to farmers associated with the use of this herbicide were as follows:

Labor:

For hand weeding, 10 mandays/ha in June/July and 8 mandays/ha in August/September is needed. For herbicide, 4 mandays/ha at planting, including carrying water is needed in June/July. Labor is reduced by about 14 mandays/ha with herbicide use. Labor in the peak June/July period is reduced by 6 mandays/ha.

Cash:

About 66 per cent of labor for weeding is hired, i.e. about $ 600/ha in cash expenditures in June-September assuming a wage rate of $50 per day. Herbicide use costs about $ 800/ha in June in cash expenditure. That is herbicide use requires $ 200 more in cash and cash will be needed earlier in the season.

Equipment:

A backpack sprayer is needed for herbicide application. However, many farmers already own a sprayer for insecticide application which could be adapted. Also, a rental market exists for sprayers at $50 per day.

Intercropping/
Multiple Cropping:

A small percentage of farmers who practice intercropping will have to change to maize monocropping. Also some residual effects are possible for those farmers who plant beans immediately after maize.

Yield:

Agronomists estimate [illegible] 0.5 t/ha in yield due to [illegible] likely because of more timely [illegible]

Animal Feed:

Minimal use of weeds from [illegible]

usually generate much improvement over current farmer practices unless combined with other changes such as a new variety. In situations where the crop or the use of a particular input is relatively new or where the farmers' environment is changing very rapidly over time, experiments to investigate levels and timings of practices currently being used by farmers may be useful.

If a solution is proposed for inclusion in on-farm experiments for the purpose of formulating farmer recommendations, then those inputs must be locally available to the farmer. In many cases this might eliminate the most efficient solution to the problem. However, experiments might still be planned using inputs not locally available in order to provide information to policy makers on the benefits of making the input available.

11.3 Farmer Changes from Using Technological Components

For each alternative technological component identified as a solution to problems limiting production, the researchers should now establish a list of all changes to the farmer from using the component. Here a knowledge of farmer circumstances will be important. It is important that the changes be noted specifically (e.g., not only how much additional labor but also when that labor will be needed). A listing of changes involved in introducing a new weed control technology for maize is shown in Example 11.1.

11.4 Economic Costs and Benefits in Potential Technological Components

The changes listed for each technological component are now valued as far as possible in terms of costs and benefits to farmers for all components involving significant changes in costs. As a rough guide, if the total cost of the change (i.e. all costs of inputs, labor, etc.) is below the equivalent of 0.2 tons of grain per hectare, this economic analysis will often not be useful because we will not be able to measure such small changes, nor will the farmer tend to note these yield differences. In many cases this eliminates economic analysis of changes in variety, planting density and timing, and method of application of inputs, all of which are often (but not always) low cost changes. Change involving chemical inputs (herbicides, fertilizers and insecticides) and equipment (method of land preparation, planting, etc.) will usually require economic analysis.

The procedures for this economic analysis are contained in the CIMMYT manual, *From Agronomic Data to Farmer Recommendations.* Cost data are not difficult to obtain and many costs will be available from the survey work. It is, however, quite difficult in many cases to estimate benefits. Here the agronomist can choose a "reasonable" level of the input and provide an estimate of what the yield increase might be. Where there is much uncertainty different estimates might be tried (e.g., a pessimistic and an optimistic estimate). Alternatively the researchers can estimate the yield increase *required to cover the cost of the input* and then decide what are the chances of that yield increase being feasible. This type of calculation is shown in Example 11.2. Another guide to possible levels of inputs and benefits will come from innovative farmers in the area who might already be using the input. For experiments which have the objective of making immediate recommendations to farmers, the current prices of the input should be used. However, experiments which have a longer

Example 11.2: Partial Budget for Nitrogen Fertilizer Use

In a wheat area, a nitrogen deficiency was noted. The field price of wheat (farmers' selling price minus harvest and transport costs) was \$2.10/kg and the field price of urea (buying price plus transport costs) was \$3.50/kg. (Urea contains 46 per cent nitrogen.) Labor to apply urea by broadcasting was estimated at only one manday/ha valued at \$80/manday. Therefore the cost of applying 60 kg N/ha was estimated at $(\frac{60}{.46} \times 3.50) + 80 = \$537$. Assuming a cost of capital of 35 per cent in this area and converting to equivalent grain yield of wheat, the increase in yield of wheat to pay the cost of urea is $\frac{537 \times 1.35}{2.10}$ or about 380 kg/ha. Researchers estimated that under farmers' conditions the likely increase in yield in one recommendation domain with higher rainfall would be at least half a ton, thus justifying a [illegible] The likely increase in yield in the [illegible] recommendation domain was less [illegible] would only marginally pay the cost [illegible] A nitrogen experiment was also [illegible] drier area but at only one [illegible] somewhat lower levels of [illegible]

run objective might be evaluated using other assumptions on prices. For example, if fertilizer is in short supply and has a black market price well over the official price, the economic analysis using the black market price might indicate that fertilizer is not likely to pay on the crop in question, and therefore, should not be included in on-farm experiments to provide immediate recommendations. However, if the black market price is temporary or if the researchers want to show policy makers the benefits of increased fertilizer availability, then they might still include some fertilizer experiments in the program.

11.5 Matching Potential Technological Components to Farmer Circumstances

Last but not least is the process of prescreening technological components against farmer circumstances. Here all changes that farmers must make in order to use each technological component must be matched against farmer circumstances. This is particularly important in the case of changes, such as variety or time of planting, for which no economic analysis of costs and benefits was done. In all cases too we are alert to possible unacceptable levels of risk imposed by the component on the farmer.

The matching of potential technological components and farmer circumstances can best be illustrated through examples. In table 4 a list of possible farmer circumstances is matched against possible varietal characteristics for selecting maize varieties for on-farm testing or for establishing breeding priorities. Those circumstances favorable to a given variety's characteristics are listed on the left and those unfavorable on the right. To avoid redundancy we have listed a circumstance in only one column. For example, late season drought is favorable to earlier varieties and it is understood that late season rains are not favorable to an earlier variety. This is not meant to be an exhaustive list of varietal characteristics or circumstances.

Of course, yield is an overriding factor in choosing varieties but the desirability of increased yield may be modified by many other varietal characteristics (e.g., earliness, grain type, height, pest and disease resistance and storage quality).

Table 4. Matching of Varietal Characteristics Against Farmer Circumstances for Maize

Varietal Characteristics	Circumstances Which Favor This Varietal Characteristic	Circumstances Which Do Not Favor This Varietal Characteristic
Higher Yield	All circumstances with modifications as below:	
Earlier	1. Potential for more intensive cropping 2. Risk of early or late season drought or frost 3. Early season food shortage	1. Risk of mid-season drought (e.g. flowering time) 2. Move harvest into wet period
Shorter	1. Lodging a problem 2. More intensive technology (e.g. N fertilizer) being introduced	1. Maize doubled prior to harvest to facilitate drying
Stem Strength	1. Stem lodging problem 2. Intercropping with climbing beans	
Specific Insect/Disease Resistance	1. Specific insect/disease problem	1. Cheap pesticide already widely used
Storage Quality	1. Subsistence production and traditional storage methods 2. High seasonal price swings	1. Maize largely a cash crop 2. Insecticide used in storage
Grain color & taste same as local variety	1. Subsistence production 2. Price differences based on grain characteristics	
Easy to Shell	1. Subsistence production and shelling by hand	

Table 5. Matching of Farmers Circumstances Against Technological Components Commonly Researched for Maize

Common Types of Agronomic Experiments	Circumstances Which Favor This Type of Experiment	Circumstances Which Do Not Favor This Type of Experiment
Fertilizer (e.g. N,P levels)	1. Intensive cropping systems (2-3 crops/year) especially continuous maize. Reduced opportunities for fallow because of population pressure	1. Available and cheap supplies of organic manures or manures available within the farm (no cash expense)
	2. New varieties available with greater fertilizer response	2. Highly variable rainfall with considerable risk of low yields or complete crop losses
Weed Control (e.g. cultivation v herbicides)	1. Obvious weed problems in early growth stage (e.g. first 40 days) usually due to labor bottleneck affecting the amount *and* timing of weedings	1. Most weedings done by family labor without cash expenses (herbicides require cash)
	2. Cost of herbicide less than cost of cultivation	2. Maize intercropped with broad leaf crop complicating application
	3. Hand weeding on time difficult because of too much or too little rain	3. A crop immediately following maize is sensitive to some herbicide residuals
		4. Weeds are fed to animals or used for other purposes
		5. Water is not easily available for herbicide application
Density/Spacing (farmers' versus higher density and closer spacing)	1. Availability of higher yielding, shorter, smaller leaf varieties.	1. Considerable risk of drought
	2. Farmers beginning to use more intensive practices (e.g. fertilizer)	2. Intercropping is important
	3. Farmers beginning to use machine planting	3. Weeding by hand or animal requiring sufficient row width
Insecticide (application of chemical insecticide)	Obvious problem of insect damage to farmer's maize in some seasons (e.g. substantial reduction in density of plants)	
Tillage Method (e.g. herbicide zero v conventional tillage)	1. Problems preparing land on time because of labor or machinery shortage or weather	Same as for Experiments for weed control
	2. Cost of herbicide use less than cost of tractor hire (if tractors are used)	
Time of Planting	1. Climate pattern suggests flexibility in planting time	1. Maize immediately follows another crop
	2. Possibility to avoid hazards such as disease, drought or frost by changing date	2. Weeding/planting/harvesting is shifted into a period of serious labor shortages
	3. An earlier or later variety is being introduced	
Method and Time of Application of Input (e.g. more precise placement and split application of fertilizer)	1. Most farmers are already using the input	1. Change of method/time of application would require labor at the labor bottleneck period
	2. Input is expensive and needs to be more effectively utilized	2. Method requires machinery

For example, an earlier variety might enable a farmer to move to more intensive cropping, e.g. two to three crops per year. An earlier variety might also affect his risk situation (e.g., reducing risk in the case of late season drought or frost). Storage quality is a characteristic which is affected by the economic circumstances of the farmer. If seasonal price swings are small and farmers sell most maize, storage quality will be less important to farmers, and vice-versa.

Table 5 matches a series of agronomic research components in maize against farmer circumstances. Many of these circumstances already have been considered and arise from the list of changes involved in using the new technological component. Some changes will have been included in the economic analysis of costs and benefits but many will be difficult to value in this economic analysis. For example, in the experiment to compare hand cultivation and chemical weed control, several factors might conflict with farmer circumstances even if the cost of herbicides is lower than hand cultivation. Use of some herbicides might not be compatible with the farmers' rotation and intercropping practices. Alternatively, herbicides may entail a cash expense at a time when cash is scarce. Weeds might have benefits as animal feed. There might also be some benefits of herbicide use if it enables more timely weeding—for example, when the ground is very wet. These types of costs and benefits are usually quite difficult to value in monetary terms and a more subjective accounting of the importance of these changes to the farmer must be made.

Finally, the proposed technological components should be examined for their impact on cash needs and labor requirements. In both cases the level and timing of the requirements may be important. The cash needs of a new technology should, as far as possible, be minimized unless there is an efficient credit program already operating. In general, packages which increase cash expenses 50 per cent above cash expenses of the current crop technology will create problems for the farmer and will require additional returns to offset this need. Moreover, cash expenses occuring at a time of cash in-flows will be easier to meet than at a time when cash is short and is needed to purchase food. Labor inputs that occur at a particularly busy time may also create difficulties. Higher density planting of maize may not require much additional labor but when combined with other parts of a technology, such as fertilizer application at planting, the total labor requirements for planting and fertilization may increase by 50 per cent. This increase could be critical to a farmer short of labor (and cash) at planting time if there is little flexibility in timing of planting because of weather conditions.

So far we have considered varietal characteristics or technological components as separate entities. In practice, there will be strong interactions between them so that we will want to match groups of technological components against farmer circumstances. For example, nitrogen fertilizer may appear as a promising component but only if a shorter variety less susceptible to lodging is available. These two components would then be considered together as a potential technology.

The procedures described in this chapter are a systematic way of screening technologies to solve local problems. However, the final choice of technological components must be made by the researchers in weighing the relative strengths and weaknesses of each. Farmer circumstances are by no means rigid. They are subject to change overtime as the result of new price relationships or government policy decisions. Moreover a technology that conflicts with farmer circumstances such as labor constraints or drought risk may still be acceptable to the farmer if the economic returns to the technology are high and the conflicts are not very severe. As the farmer may be willing to make these trade-offs, so should the researcher.

SELECTED FURTHER READINGS

CHAPTER 11

1. Anderson, J.R. and J.B. Hardaker, "Economic Analysis in the Design of New Technologies for Small Farmers," A. Valdez, G.M. Scobie and J.L. Dillon (eds.), *Economics and the Design of Small Farmer Technology,* Iowa State University Press, 1979.
(A good review of the limitations of various analytical techniques in prescreening technologies.)

chapter 12 examples of planning on-farm experiments

This chapter draws together various experiences of planning experiments based on the procedures presented in Chapter 11. Two of these experiences emphasize planning an on-farm experimental program. Another focuses on priorities in varietal development to be emphasized in on-station research.

12.1 Planning On-Farm Experiments for Maize in East Africa

Our first example is based on a tropical maize-growing area in East Africa characterized by the recent widespread adoption of hybrid seed and fertilizer into a farming system in which labor at planting is one of the major bottlenecks.

In fact, most of the agronomic factors limiting maize production were due to the labor problem. Many fields suffered from late season moisture risks due to late planting. The 170-day hybrids available to farmers required planting at the beginning of rains to minimize moisture risks later. Nonetheless, 50 per cent of plantings were made with only 140 days of moisture availability. Although farmers started planting before the rains on low-lying areas, because of labor constraints they had to stagger plantings. In addition, many fields were damaged by water-logging early in the season because farmers switched from traditional ridge planting to planting on the flat which required less labor and enabled farmers to speed-up planting. Weeds were also a problem. Fifty-five per cent of fields were weeded only once and this was when the maize was at an average height of 60 cm. In this case, weeding of maize conflicted with later plantings of the earlier maturing subsistence crops, finger millet and beans. Also, the second fertilizer application was made after the first weeding when maize was already 75 cm high—again due to labor shortages preventing earlier weeding. Finally, unrelated to the labor shortage, many maize fields suffered from stalk borer damage late in the season although few farmers were using insecticides.

One approach to alleviating the problems of late planting, water-logging, weeds and late fertilizer application would be to find ways of reducing the labor constraint, such as use of tractor or oxen cultivation or herbicide use. However, there was evidence that farmers faced a severe cash constraint and that solutions requiring considerable cash would compete with fertilizer use in maize. Fertilizer purchases represented 54 per cent of cash production costs for maize, and 25 per cent of farmers' cash incomes. Moreover, custom oxen and tractor services were being used by a few farmers and it was felt that other measures to increase cash incomes of farmers would enable more of them to use these services.

The immediate solutions, therefore, centered on selection of an earlier variety which could be planted according to farmers' current planting schedule and mature by the end of the rains. Earlier varieties were available for testing on farmers' fields. These varieties were somewhat shorter, probably requiring higher densities, hence variety x density experiments were included to determine optimal densities. Experiments were also designed to determine best use of available fertilizer with earlier varieties (e.g., time and method of application). Finally, an insecticide experiment was designed to determine if there was an economic response to insecticide treatment of stalk-borers. These experiments were designed for implementation on representative farmers' fields.

12.2 Planning On-Farm Experiments for Maize in the Andean Region

A survey of farmers in a highland maize-producing area of the Andes showed that one of the major potentials in the area was an earlier variety to enable farmers to plant a second crop—peas or lentils. Sixty per cent of farmers preferred an earlier variety even if yields were reduced. By asking farmers about the trade-offs between earliness and yield losses it was estimated that a variety about five weeks earlier would best suit their needs and that they would be willing to use such a variety even if it yielded up to 20-25 per cent less than current varieties. Varieties meeting these earliness/yield requirements were selected from available varieties being developed on-station and were included in on-farm varietal experiments. Of course in this situation the successful adoption of an early maize variety might lead to a reduction of maize production but, more importantly, farmers' incomes would increase as a result of the second crop.

In addition to variety, researchers diagnosed the factors limiting production as weeds, fertility and insect damage. Since weeds were an important source of animal feed in the area, it was not considered feasible to use herbicide weed control methods until an alternative forage source was found. One such source is the stripping of maize leaves and tassels and the thinning of maize plants. However, almost all maize was interplanted with local beans which, because of their aggressive climbing habit prevented leaf stripping. It was therefore decided to look for beans with a different growth habit, that would allow some stripping. This bean type also gave more flexibility in choosing early maize varieties which were not adapted to intercropping with the local climbing bean. At the same time the breeding program began to look for maize varieties which provided tillers which could be removed early in the crop cycle to feed animals.

Most farmers were applying some animal manure but this was insufficient to sustain high maize yields. Few farmers were using chemical fertilizer. The on-farm experiments therefore included experiments to determine economic doses of nitrogen and phosphorus.

Insect damage from ear worm was not a major problem but still was felt to contribute to a yield loss of from 10-15 per cent or about 200 kg/ha. Potential insecticide treatments were then prescreened to identify treatments with a cost of less than 200 kg/ha in grain equivalents. Costs included in prescreening the insecticide treatments included the cost of the insecticide, the hand sprayer, the labor for application and a 25 per cent capital charge on these costs. The procedure was similar to that given in Example 11.2 of Chapter 11.

The above experiments—variety, fertilizer and insecticide—were designed so that the non-experimental variables reflected farmers' practices. Information on farmer practices was obtained from the survey and generally showed that representative farmer practices were maize intercropped with beans, fertilization with animal manure, no insect control and irrigation only in some recommendation domains.

Finally, the survey helped in choosing sites for locating the experiments. Information on slope, soil texture and irrigation helped establish characteristics of representative farmers in the region. Moreover, farmers were asked in the survey if they would be willing to host an on-farm experiment. This provided a long list of farmers from which to choose sites.

12.3 Guiding Research on Tropical Maize Varieties in Dry Areas of Eastern Africa

In a tropical maize area of Eastern Africa, breeding efforts on maize had already focused on finding earlier maize varieties to better fit the relatively short period of 75 days of reliable rains. Current farmers' varieties required 115-120 days to mature and therefore often suffered severe losses when rains started late, when there was a mid-season gap in rains or when the rains finished early. A survey of farmer circumstances in the area diagnosed other elements of the farming system which reinforced the need for emphasis on early varieties. First, farmers largely depended on maize as an early source of food in the critical period before other crops were harvested. An earlier, more reliable harvest would suit farmers of the area even better in satisfying food needs in this period. Second, early maize varieties planted on low-lying areas would increase the potential area and reliability of a second crop, such as beans planted on residual moisture immediately after maize. Third, the planting of the main crop of an early variety of maize could be done later when rains were more reliable and relieve current labor bottlenecks for planting and weeding that farmers experienced with present varieties. This might enable larger areas to be planted or better management practices to be carried out, using the cash saved from hiring labor in the peak labor period. Finally, with an early variety the increased reliability

of a maize crop would reduce the need for planting security crops such as sorghum and cassava and again provide additional resources for increasing the area and management of the preferred food and cash crop, maize.

The survey also uncovered other characteristics of a variety desirable to farmers in the area. These included resistance to lodging, since ears of lodged plants were often damaged by rats in the field; storage quality, since maize was a staple food eaten throughout the year, and palatability of the varieties when they were processed into the preferred local maize foods. These characteristics could then be used to prescreen early varieties of maize prior to testing on farmers' fields.

SELECTED FURTHER READINGS

CHAPTER 12

The following are empirical applications of the procedures described in this manual.

1. Collinson, M.P., "Demonstrations of an Interdisciplinary Approach to Planning Adaptive Agricultural Research Programs; Serenje District, Zambia, "Report No. 3, CIMMYT Eastern African Economics Program, Nairobi, 1978.

2. Harrington, Larry, "Farmer Practices and Problems in Northern Veracruz," CIMMYT, El Batan, Mexico, June, 1979. (Unpublished manuscript)

3. Benjamin Alan, "The Agro-Economic Context of Maize Production in Three Valleys of the Peruvian Sierra," CIMMYT, El Batán, 1980. (Unpublished manuscript)

4. Bruce, K., D. Byerlee and G. Edmeades, "Maize in the Mampong-Sekodumasi Area, Ghana: Results of an Exploratory Survey." CIMMYT Economics Working Paper, 1980.
(Reports methods and results of an exploratory survey used to design an on-farm experimental program.)

GLOSSARY OF TERMS

Agro-Climatic Environments: Areas (not necessarily contiguous) where a crop exhibits roughly the same biological expression, so that we would obtain, for example, similar variety or fertilizer responses within a given environment, *everything else being equal.*

Base Practices: Management practices which are generally representative of practices of farmers in a given recommendation domain. These practices serve as a reference for comparing potentially improved technologies against farmers' present technology in on-farm experiments.

Best-bet Components: Those components which result from the prescreening process that promise significant increases in incomes at reasonable levels of risk within the resources available to farmers.

Exploratory Survey: A process by which the researchers traverse the target regions and informally interview farmers and other persons knowledgeable of agriculture, in order to arrive at a tentative understanding of farmers' existing technology for the target crop and constraints limiting farmers' production and income.

Farmer Circumstances: All those factors which affect farmers' decisions with respect to use of a crop technology. They include natural factors such as rainfall and soils and economic factors such as markets, the farmers' goals and resource constraints.

Farming System: The total of production and consumption decisions of the farm-household including the choice of crop, livestock and off-farm enterprises and food consumed.

Farming System Interactions : Interactions between different crops, livestock and non-farm enterprises of the farming system which influence the choice of technology for the target crop—for example, the planting of a high density of maize so that thinnings can be used to feed livestock.

Field or Area Sampling: Sampling methods in which a field is chosen randomly and then the cultivator of the field interviewed. Fields may be chosen by randomly locating coordinates on a map of scale 1:50,000.

Formal Survey: A survey of randomly chosen farmers who are interviewed by trained interviewers using a written questionnaire in order to provide quantitative data on farmer circumstances.

Informal Farmer Interviews: Interviews with farmers usually conducted by researchers themselves without a fixed questionnaire and with minimal use of pen and paper. The interview is structured according to a checklist of information but with flexibility to explore certain practices or problems in more depth depending on the farmer's responses.

Limiting Factors: Those agronomic factors such as weeds and pests which limit productivity. Most limiting factors are related to characteristics of farmers'natural and economic circumstances (e.g., weeds may reflect labor availability).

Management Practice: The actual use of a technological component defined in terms of the type, amount, and timing of the component.

New Technological Components: Practices or inputs which are yet to be developed or whose performance under farmers' conditions cannot be predicted with confidence. Examples are varieties yet to be created or new herbicides with which researchers have little or no experience.

On-Farm Experiments: Experiments conducted in farmers' fields usually with the immediate aim of developing technological recommendations for farmers. On-farm experiments may be managed by researchers or farmers or both.

On-Farm Research: Research in farmers' fields with farmers involved to formulate improved technologies. There are typically two types of interrelated activities: a) surveys of farmer circumstances, and b) experiments.

Prescreening Technological Components: The process of choosing, from many potential components, a few components for on-farm experimentation which address critical farmer problems and which are feasible given farmers' circumstances.

Random Sample: A sample drawn so that every unit in the population or sub-population has an equal probability of being selected.

Recommendation Domain: A group of roughly homogeneous farmers with similar circumstances for whom we can make more or less the same recommendation. Recommendation domains may be defined in terms of both natural factors (e.g., rainfall) and economic factors (e.g., farm size).

Secondary Information: Information obtained from published and unpublished sources such as censuses, government reports and research publications.

Stratification: The process of dividing a population into relatively homogeneous subgroups in order to increase sampling efficiency. Stratification follows as closely as possible the definition of recommendation domains.

Target Crop: A crop which is currently, or has potential to be, a major crop in the system and for which there are available technologies with potential to increase farm production and income. In this manual the examples always refer to maize or wheat as the target crop.

Target Region: A relatively homogeneous region chosen for an on-farm research program. The choice of the region may depend on crop production potential, government goals with respect to income distribution and the available infrastructure for doing research in the region. On-farm research procedures are most efficiently implemented when focused on a relatively homogeneous region or group of farmers.

Technological Components: A specific part of a technology such as variety, fertilizer or herbicide.

Technology: The combination of all the management practices used for producing or storing a given crop or crop mixture.

Two-Stage Sampling: A sampling procedure in which sub-populations such as villages are first selected and then units, such as farmer groups are chosen within each selected subpopulation.

Correct Citation: Derek Byerlee, Michael Collinson, *et.al.* "Planning Technologies Appropriate to Farmers—Concepts and Procedures," CIMMYT, Mexico, 1980.

CIMMYT. The International Maize and Wheat Improvement Center (CIMMYT) receives support from government agencies of Australia, Canada, Denmark, France, Japan, Mexico, Norway, Switzerland, The Federal Republic of Germany, The Netherlands, The United Kingdom, USA, and Zaire; and from the Inter-American Development Bank, The Ford Foundation, The Rockefeller Foundation, United Nations Development Programme, and the World Bank. Responsibility for this publication rests solely with CIMMYT.