Participatory Development of Agricultural Innovations

Procedures and Methods of On-Farm Research

J. Werner

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Preface

Agricultural innovations have to overcome farm level constraints, not only regarding farmers' and their families perception but also with regard to the ecological, economic and socio-cultural environment farmers operate in. The understanding, that only working together with farmers guarantees the adaptability of innovations led GTZ already in the early eighties to prepare a guide on On-Farm-Research procedures to be used in rural development projects, the "On-Farm Experimentation Handbook" by Kurt G. Steiner. The book found a worldwide appreciation and became a valuable tool for researchers and extensionists in developing "client oriented" innovations.

"The Steiner" - as the book became to be known - ran out of print quickly. At the same time, methodologies, especially in the field of farmer's participation, developed further and a revision of the guide proved necessary. The person who took up this task, Jürgen Werner, can draw on a vast personal experience with on-farm experimentation. In addition, he evaluated most recent experiences of projects of the German Technical Cooperation and the Swiss Development Cooperation (SDC) in various parts of the world. The outcome is a completely revised book, although essential elements of Steiner's handbook of 1986 have been integrated.

The book is to give a practical guide for On-Farm-Research to all those who have at their hearts the improvement of the living conditions of rural people in developing countries.

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Without the support and confidence of GTZ, namely M. Bosch, and SDC (Swiss Development Cooperation), namely W.Graf, it would not have been possible to write this book or to accumulate the experience on which it is based.

H.G. Schön prepared drafts on statistical issues and computer software and made valuable suggestions concerning trial design and analysis.

Many colleagues read drafts and provided important comments. Among them were J.Ashby, G. Hollenbach, A. Jäckle, M. Menzi, T. Schwederski, K.G. Steiner, H. Waibel, F.J. Wang'ati, ...

Thanks is due to CIAT and J. Ashby for permission to use part of the handbook "Evaluating Technology with Farmers". The mechanisms of communicating with farmers in on-farm research could not have been clarified better than in J. Ashby's text.

Many issues raised here are based on discussions and observations made in development programmes in East and West Africa which I had the opportunity to visit in 1990 and 1991. Thanks is due to the colleagues in these programmes for their hospitality and support.

Most obliged I am to farmers and colleagues in Liwonde, Malawi and Lamu, Kenya who I had the pleasure to work and to live with. The ideas presented here would not have been developed without their cooperation.

February 1993 Jürgen Werner

Table of Contents

Chapter 5 Experimentation

Chapter 6 Tools and methods for data analysis and presentation

List of Tables and Figures

Chapter 1

Tables **Page**

Chapter 2

Tables

Figures

Chapter 3

Tables

Figures

Chapter 4

Tables

Figures

Chapter 5

Tables

Figures

Chapter 6

Tables

Figures

Chapter 1 Introduction

Chapter 1 Introduction

1.1 The subject of the book

This book deals with procedures, tools and methods of on-farm research ("OFR"). Its **aim** is to assist in the development of innovations which

- correspond with farmers' goals, preferences and resources;
- are environmentally sound and
- economically viable.

Important **elements** of on-farm research are
- farmers' participation in drawing up a research agenda;
- experimentation by farmers in the farmers' environment;
- farmers' and researchers' joint assessment of options.

On-farm research is related to and uses pragmatically elements of approaches such as *farming systems research, farmer participatory research, participatory technology development, recherche développement, recherche action* and others. All these approaches have a **common goal:** increasing farmer participation in the development of agricultural innovations. They were all, however, developed at different times, at different places or by different groups and therefore vary from one other to a greater or lesser extent.

On-farm research also uses elements of *rapid rural appraisal, participatory rural appraisal* and related diagnostic instruments for assessing the demand for innovation and the options for experimentation.

1.2 The structure of the book

The book comprises two parts in addition to the introduction:

Part I, "Principles and procedures", is the heart of the book. It contains, so to speak, a basic construction plan with some advice on how to adapt it to different requirements. A sufficient understanding of this is a precondition for a satisfactory application of on-farm research tools and methods.

Part II, "The Tools", describes how to make a reasonable choice of the tools and methods which can be applied in on-farm research. Emphasis is laid on a brief presentation with enough detail to facilitate an easy practical application.

Annexes to some chapters of the book contain practical examples which foster the understanding of the research process or show how tools and methods work in practice.

1.3 The users of the book

1. The book is written mainly for **people actively involved in the planning and implementation of OFR-programmes**. This group includes :
- **professionals** working in research programmes or research components of rural development projects and
- **extension workers** who devote part of their time to the development of innovations, often not even considering this activity to be research.

For those belonging to one of these groups, Part I of the book is an opportunity to refresh or improve their understanding of OFR principles and procedures.
For researchers, the set of tools and methods provided can assist them to **achieve farmer participation** in the research process while obtaining reproducible data. The tools and methods will help **extension workers** to define appropriate extension contents in a **systematic** process.

2. **Development professionals** concerned with the design of development projects involving OFR-programmes may find the principles and procedure described in Part I of the book useful as a conceptual base.

1.4 How to use the book

The structure of the book facilitates the study of different chapters and subchapters independently and selectively.

Nevertheless, it is recommended that Part I of the book be read completely before dealing with the tools and methods of Part II in order to acquire a sufficient understanding of the principles and procedures which form the basis.

Relevance of the tools and methods to a particular project approach

Not all the tools and methods presented here will be really relevant to every kind of programme.

Table 1.1 shows some examples of how different tools and methods are relevant to various project approaches:

All the described tools and methods are relevant to **on-farm research programmes** aiming to **develop "prototype technologies"** adapted to the ecological and socio-economical conditions of the research area. A relatively small selection of farmers will usually participate in the research. Considering the heterogeneity of farm conditions and of farmers' goals and preferences, the result of the research can therefore not be one "message" for all farmers in the area, but rather a basket of options from which farmers can select and develop their own solution with the help of extension workers.

Extension programmes should mainly use participatory methods -informal, such as the dialogue on innovation, as well as formal ones, like the adoption survey. The aim can be to select potentially appropriate innovations from a given basket of choices and to test and assess them jointly with farmers. In extension programmes with a **community development focus** the informal methods can help to strengthen farmers' own ability to analyze their problems or potentials and to identify and test potential innovations by themselves.

The choice of technologies is largely predetermined in **commodity oriented** programmes. Emphasis will be on methods for the identification of potential clients and the assessment (before and after experimentation) of which technologies meet the demand of potential clients and comply with their conditions. In a **broad approach** without limitations concerning the choice of technologies, the whole set of tools and methods is relevant to explore demand for innovation, identify potential options, experiment and eventually assess tested options.

Application of tools and methods to the problems facing a particular programme

If the programme has already commenced, not all the potential tools and methods will be applied, nor the "research process" started afresh. The tools and methods to apply depend on the task to be carried out or the problem actually encountered.

Table 1.2 lists some problems commonly encountered by people working in on-farm research programmes and refers to the chapters of this book which can help to solve a particular problem.

Tools and methods need to be adapted to a specific situation

Those inexperienced in carrying out on-farm research are well advised to stick to the "operating instructions" given for the different tools and methods. Every situation will, however, require its own specific tools and the creative adaptation of their "operating instructions". After researchers have gained some experience, a touch of courage to develop approaches which are appropriate to a particular situation will be rewarded with better results.

1.5 Some notes on terminology

The term "research" as it is frequently used in this book refers to an activity rather than to an institution. In the context of this book "research" is broadly defined as an investigation into the demand for or the appropriateness of an innovation. This activity is carried out by research institutions as well as by extension organizations. The term "researcher", as it is used here, includes the extension worker searching for or developing appropriate extension contents as well as the staff of a research institution.

The terms "extension worker" or "researcher" are not gender specific. Both women and men can carry out extension as well as research functions equally well. Likewise, the term "farmer" applies to both male as well as female "farmers" and includes the male or female head of the farm household as well as his or her spouse.

Table 1.1: Relevant tools for different project approaches

Distin-guishing feature	Project approach	Relevant tools and methods
Project function	Research project	The whole set of tools and methods to explore demand, identify options, experiment and assess trial innovations, in order to **develop technology**
	Extension oriented project	Emphasis on farmer participation in exploring demand for and assessing trial innovations, in order to **adapt technology to farmers own conditions**
	Community development oriented project	Emphasis on participatory tools and methods in order to **strengthen farmers innovative capacities**
Scope and type of field of work	Broad "system oriented" approach (choice of technology is open, direction to be determined by project)	The whole set of tools and methods to explore demand, identify options, experiment and assess technology
	"Commodity-oriented" approach (choice of technology is predetermined)	Emphasis on identification of potential clients and assessment of given technology

Table 1.2: How the book can help if different problems are encountered (I)

The problem	Recommended chapters of the book
You are not sure how to get the programme started.	2
You do not know how you will benefit from on-farm research.	2
You do not know which problems farmers in your research area have.	2.4.1, 4.2.2, 6.1.4
You are not sure whether you are working on the right problems and potentials.	2.4.1, 4.2.2, 6.1.3
You do not know which farming practices farmers in your area apply.	4.2.1, 4.2.2, 6.1
You have received a lot of survey results from the socio-economics department but do not know how to utilize them in the planning of the experimental programme.	2.4.1, 2.4.2
You do not know which type of technology to give priority to in your research.	2.4.1, 6.1.3, 6.1.5
You are not sure how to take "farmers' practice" into account in the experimental design.	5.1
You are not sure whether your technologies correspond with farmers preferences.	4.2.2, 6.1.6

Table 1.2: How the book can help if different problems are encountered (II)

The problem	Recommended chapters of the book
You do not know whether you are working with the most appropriate selection of farmers.	6.1.4
You feel you have a problem in communicating with farmers.	3
Farmers do not cooperate.	3, 2.4.1, 2.4.2
You do not have time to visit your trial farmers often enough.	5.3.1
Farmers apply experimental treatments incorrectly.	5.1, 5.3.2
Farmers management is not up to standard .	2.3, 5.1
There is not sufficient staff to supervise the trials properly.	5.3.1
You have too little money to run the programme as it was planned.	5.3.1
Your trial plots are always planted too late.	5.3.1
One or more farmers harvested trial before yield measurements were taken.	6.2.1
Records received from field staff are incomplete.	5.3.2

Table 1.2: How the book can help if different problems are encountered (III)

The problem	Recommended chapters of the book
Your data is difficult to analyze because some plots were destroyed by animals.	6.2.1
Trials were to be analyzed across sites but the number of farmers is not the same at all sites.	6.2.1
Trial results show high variability.	6.2.1
You are not sure whether or to what extent your technologies are adopted by farmers.	4.2.3, 6.2.2.4
You do not know why farmers do not adopt suggested technologies.	4.2.2
Extension officers do not utilize your results.	2.4.5

Part I The Approach

Chapter 2 Principles and procedures of on-farm research

Chapter 2 Principles and procedures of on-farm research

2.1 Evolution of an approach

The results of many rural development projects aiming to improve the living standards of the rural population in developing countries have often been disappointingly poor. This was largely because agricultural innovations propagated to increase agricultural productivity were not adopted by small resource-poor farmers as was expected. It is now more or less generally accepted that the reason for this is not farmers ignorance but the inappropriateness of the supposed innovations (see Table 2.1).

The slow progress in the development of smallholder agriculture in most developing countries contrasts sharply with the rapid development of agriculture, in the industrialized countries. Many explanations for this are given in the extensive and ever-growing literature on farmers' role in and their benefits from agricultural research and extension. Some explanations cite the high diversity of ecological conditions, the complexity of production systems and the high risks caused in particular by unstable climatic conditions (Chambers et al., 1989). Simple, high-input, systems that were successful with "industrial" or "green revolution" agriculture do not succeed well under such conditions.

Better adapted technologies were expected from "on-farm research" methods developed in the early 1980s. Smallholder production conditions and systems were systematically analyzed and production constraints defined by researchers as far as possible from the farmers point of view. Potential solutions were subsequently tested in farmers fields, i.e. under farmers' own environmental conditions. Economic considerations became as important in the trial evaluation as the agronomic analysis.

The results achieved were, nevertheless, still unsatisfactory. Researchers had difficulty in considering the production goals and decision criteria of smallholder farmers in the development of agricultural innovations. The complex goals and decision criteria of smallholder farmers are often beyond the understanding of agricultural researchers. Quantifying the value of an innovation in monetary terms, which was considered appropriate for judging the effect of an innovation, is often meaningless to a small farmer in a developing country. Not understanding farmers' goals and decision criteria increases the likelihood

of addressing the wrong problem or of valuing an innovation incorrectly. Obviously (in the words of J. Ashby, 1990) "no one specialist knows as intimately as the farmer all the many different problems and needs of the small farm household. Therefore, no other specialist is better equipped to visualize how to put a technology to work on the farm to meet those needs".

Table 2.1: Failure of farmers to adopt new technologies: how this was explained and favored remedies over the past 40 years (adapted from Chambers and Ghildyal, 1985)

Stage	Period when dominant	Explanation of non-adoption	Prescription
1	1950s 1960s	Ignorance of farmers	Agricultural extension to teach farmers the right technology
2	1970s 1980s	Farm-level constraints	Ease constraints to enable farmers to adopt (e.g.credit for inputs or implements)
3	early 1980s	Technology does not fit RPF conditions	Researchers to understand conditions and generate technologies which fit
4	late 1980s 1990s	Technology does not match with RPF goals	Farmers participate in planning and evaluation of research programs

RPF = Resource-poor farmers

The current trend is therefore towards increasing the involvement of farmers not only in the physical implementation of trials but also in the definition of research needs and the design and evaluation of programmes in order to utilize their specialist knowledge. This kind of **participatory approach** to the development of innovations, called "on-farm research", is the subject of this book.

2.2 Researchers, extension workers and innovation

Researchers and extension workers both play their role in the development and dissemination of innovation. But are extension workers and researchers really required to initiate an innovation process?

So-called "traditional agriculture" can be seen as the long-term result of a continuous innovation process carried out by farmers for generations. Traditional agriculture is not static. It does not have the same face as 100 years ago. Farmers themselves conducted their own type of "trial and error" experimentation to continuously adapt their farming practises to changing circumstances or to incorporate new ideas they picked up.

Example:
The literature shows many examples of successful innovations developed by farmers. An example is that of a group of Kenyan farmers who were compelled by increasing land scarcity in the highlands to settle at the coast, in a completely strange environment. Forced by natural circumstances, they developed a new intercropping system within 10 years without the support of extension workers or researchers. This intercropping system, consisting of cotton, maize and cowpeas, is now the core of their farming practice. Subsequent research efforts to optimize the system failed: it was apparently well developed already.

As innovation takes place anyway, the primary function of extension workers and researchers can not be to initiate innovation. They can, however, stimulate the ongoing process and give it new dimensions. New ideas produced and tested with the help of researchers can help to lift farming to a new technological level; extension workers in the function of "facilitators" accelerate the ongoing innovation process by spreading new ideas among farmers and between researchers and farmers and by encouraging farmers to try out by themselves.

2.3 Principles of on-farm research

The success of an agricultural innovation is always to some extent a matter of chance. No rules can guarantee success, but one can give chance a helping hand by observing a few simple principles:

Try first to understand farmers and their circumstances

Farmers' decision as to production and consumption are determined by their goals and preferences as well as by natural and socio-economic circumstances. These factors also determine farmers' attitude towards a new technology, and should therefore guide the researcher in the development of an innovation.

Researchers require a basic comprehension of farmers' goals and circumstances if they want to help farmers to articulate their needs or to assess options tested. Any attempt to comprehend farmers' goals and circumstances to the last detail is, however, expensive, time consuming and unlikely to succeed. More promising and less tiresome is, therefore, an approach which ensures that:

Farmers play a role in determining the course of action

Nobody has a better understanding of his different needs and the opportunities his farm offers than the farmer himself. Nobody is better able to judge which kind of technology would be required and how to get it to work on the farm. The complex decision criteria of small farmers are well beyond the comprehension of researchers. New technologies are therefore more likely to succeed, the earlier the specialized "farming systems know-how" of farmers is utilized and combined with the technical knowledge of researchers.

As farmers are the center of attention, they should also play a key role in determining the subject of research and the choice of appropriate technologies. The role of researchers is more:

- to help farmers to articulate their demand for innovation, to offer a choice of options to satisfy this demand and
- to provide the principles and methods for testing these rather than deciding what farmers need.

Options are tested in farmers' fields, under farmers management and using farmers own practice as a control

The purpose of on-farm experimentation is not so much to show the potential productivity of an innovation (this should be known already from station research) but rather to prove its feasibility under actual farm conditions. **Experimentation in farmers' fields** provides data regarding the feasibility of an innovation under the diverse ecological conditions which farmers face. Such trials **under farmers' management** show whether the technology is compatible with practices applied by farmers and works given existing resources. Experimentation which **use farmers' own practices** as the control provides an appropriate basis for comparison.

The response of farmers is a primary evaluation criterion

Early attempts to carry out on-farm research often met with failure. An important cause was that innovations were primary evaluated according to agronomic and economic criteria laid down by researchers. Eventually the "best" option (according to these criteria) was presented to farmers for their judgement – and failed more often than not to achieve acceptance. Meanwhile many "second best" options, better corresponding with farmers' goals, were already lost on the way.

Experience has shown the importance of considering farmers' goals as evaluation criterion right from the beginning of the research process. "It should not be the (final) packages of technology that are provided to farmers but (a choice of) genetic materials, principles, practices and methods for them to test and use" (Chambers, 1990). It is eventually farmers judgement which determines whether a new technology will be adopted or not. Farmers' judgement therefore also deserves to be a key criterion in the evaluation of different technical options compared in a trial programme.

The innovation must be technically sound, economically viable and warrant sustainability

The conventional agronomic and economic evaluation criteria are, nevertheless, still of importance. Costly measures to facilitate and promote new agricultural technologies are certainly not economically justified if the new technology does not prove to be superior to existing technology in agronomic and economic terms. Current approval by farmers can also not substitute for the sustainability of an innovation.

The success of an innovation is measured by its adoption

A successful technology is the one which is adopted by its target group. The research process is not finished with the publications of results showing the superior performance of a developed technology in terms of agronomic or economic criteria, but with the proof that it is applied by farmers.

A systems perspective is applied

No activity in a farm exists in isolation. They are interrelated through competition for scarce resources or when products of one farm activity are used as the basis for another. The optimization of one component or production technique of the "farming system" may require that specific characteristics of other components and production techniques be taken into consideration.

On-farm research is a step-by-step procedure

An important precondition for adoption is that farmers are able to comprehend the effects of a change of technology. The meaning of "systems perspective" should, therefore, not be misinterpreted. New "systems" or complex new technologies are very seldom adopted by farmers at once as an integral whole. Farmers adopt technological components one at a time, and not as complete package. On-farm research should, therefore, strive for a step-by-step change, bearing the systems perspective in mind.

On-farm and station-based research are complementary

On-farm research does not have the means to and should therefore not strive for the development of "new" agricultural technologies. It is rather complementary to station-based research. Its role is to explore existing and future needs for new technology and to identify technologies which satisfy these needs from the already available alternatives developed by research stations or innovative farmers.

In an efficient research system station-based and on-farm research are carried out in close cooperation. Station-based researchers consider the need for technology identified by on-farm researchers to steer their own activities. On-farm researchers in turn, draw material from the technological alternatives developed at the research stations.

Involve extension workers from the beginning

It would be desirable that every extension worker was active as an on-farm researcher himself, helping his farmers to articulate needs for innovation, to gather ideas about innovation from within the farming community and from outside and to test these ideas. This is, however, not the case in many research and extension systems.

Where on-farm research and extension functions are not carried out by the same persons or institutions, extension workers must nevertheless be involved in the research process right from the beginning.

It is often not possible that extension workers are actively involved in the actual field implementation of the research. Their participation in planning programmes and in the assessment of tested technologies is necessary, however, to improve and accelerate the dissemination of results, because:

- extension workers views concerning agricultural problems and potential solutions can be considered in the research planning,
- the feasibility of promoting results through extension can already be considered during the research process,
- continuous involvement of extension workers in the research process improves their comprehension of results eventually achieved,
- the time lag between the conclusion of an experiment and the application of its results through extension is reduced.

Table 2.2: Characteristics of on-farm research

Objectives:
- to develop innovations consistent with **farmers circumstances**, compatible with **actual farming systems** and corresponding with **farmers' goals and preferences.**

Primary location:
- farmers' fields.

Roles of farmers:
- to discover needs for agricultural innovation;
- to select from a choice of technology;
- to determine conditions and management of testing;
- to test and evaluate whether chosen technology meets demand;
- to transfer knowledge in farmer-to-farmer extension.

Roles of extension workers:
- to point out their own need for information about innovation;
- to mobilize farmers indigenous knowledge;
- to help farmers to articulate their demand for innovation;
- to evaluate feasibility of innovation within the frame of the extension system;
- to spread knowledge about innovation;
- to transfer knowledge about how to test and evaluate innovations.

Roles of researchers:
- to help farmers to articulate their demand for innovation;
- to demonstrate choice of possible technology to satisfy needs;
- to explore and use indigenous knowledge;
- to provide principles and methods to test chosen technology;
- to evaluate productivity and sustainability.

Primary criteria for assessment of technology:
- correspondence with farmers' circumstances, goals and preferences and sustainability are as important as productivity.

Primary criterion for successful technology:
- ITS ADOPTION

2.4 On-farm research: process and procedures

The development of appropriate agricultural innovations involves a number of equally important activities. The testing of production alternatives, which is often central consideration is one important stage in the process, but not the only one. More often than not, experimentation is actually the sifting out of technologies for which there is no demand, because the preparatory steps were insufficiently executed. That some technologies are inappropriate is frequently discovered too late (if at all) because the final evaluation stage is reduced to a mere application of statistical procedures on agronomic data. Better results are often achieved by reducing the emphasis on experimentation and favouring a proper preparation and evaluation.

In this book the development of agricultural innovations is broken down into five stages:

(1) exploring the demand for innovations;
(2) identifying alternatives to satisfy the demand;
(3) testing the identified alternatives;
(4) assessing the identified alternatives, and
(5) disseminating results.

The first four stages concern the **actual development** of appropriate innovations. Their **purpose** is to explore the demand for innovations and to identify, test and assess various alternatives which may satisfy the demands using appropriate **tools and methods** according to **defined criteria** (see Table 2.3).

The fifth stage -the **dissemination** of results- is important in order to ensure that innovations are not only developed but also reach the intended target groups.

A balanced execution of all of these stages of the development process is the precondition for successful results and for a satisfactory impact on the target group.

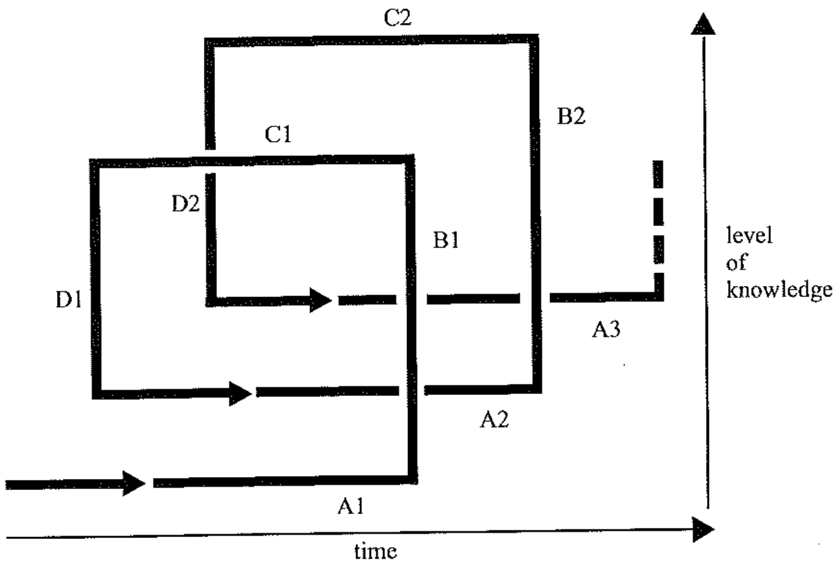
Table 2.3: The development of agricultural innovations: purposes, criteria and methods at different stages

Stage	Purpose	Criteria	Tools/Methods
Exploring demand	Explore: – Who demands innovation? – What is demanded? – Where is it demanded?	Farmers' perceived needs Present and expected problems Non-utilized opportunities	Secondary information Exploratory survey Dialogue on innovation Approp. analytic. tools
Identifying options	Identify: – Which available technologies can satisfy the demand?	Correspondence with farmers goals and preferences Ecological compatibility Economic viability Feasibility	Secondary information Dialogue on innovation Approp. analytic. tools
Testing alternatives	Collect information to examine how far alternatives comply with defined criteria	Correspondence with farmers goals and preferences Ecological compatibility Economic viability Feasibility	Experiment Observation Dialogue on innovation Farmer assessment
Assessing alternatives	Analyze, interpret and decide which of the tested alternatives comply with criteria	Correspondence with farmers goals and preferences Ecological compatibility Economic viability Feasibility Adoption	Organizing data Scaling and rating Statistical analysis Economical analysis Analysis of farmer assessment

The development of innovations is an **iterative and dynamic** process.

It is "iterative" in that the four stages of actual technology development (exploring demand through to assessing alternatives) occur in recurrent succession (see Figure 2.1). The process is "dynamic" as it is constantly readjusted on the basis of new information, reaching a higher level after every cycle of the development spiral.

Figure 2.1: The spiral of technology development in on-farm research



A = Exploring demand B = Identifying alternatives
C = Testing alternatives D = Assessing alternatives

Ideally, every new cycle of the process will be initiated with a review of the demand for innovation. The actual demand may have changed due to a change of circumstances. Or the researchers perception of demand may alter in the light of additional information gained. The modified view of demand and/or new technologies available may also change the set of potential alternatives to satisfy the demand which was identified as the basis for the testing stage.

2.4.1 Exploring the demand for innovations

The exploration of demand for innovations sets the course for all subsequent steps. Care should be taken that the on-farm research process is steered off to the right direction here. Unsatisfactory results in the development of innovations are often the result of a one-sided, superficial or incomplete approach at this early stage.

Purpose

The exploration of the demand for innovations determines the subsequent development stages in terms of
- location;
- target group and
- problems and potentials to be addressed.

It must answer questions such as:

- **Who is making demands?**
  i.e. for which group of people is the matter relevant?
- **What is demanded?**
  i.e. what problem is to be addressed by the subsequent research?
- **Where is it demanded?**
  i.e. are these problems relevant to the whole programme area, or only for part of it?

"What could we try out?" Farmers needs determine the course of action

Who is the target group ?

The obvious answer to this question is that it is **farmers** who are to benefit from the innovations to be developed.

Often **"farmers"** are mistakenly "lumped together" by programme planners as a homogeneous undifferentiated mass. Every farmer has got his own goals and is working under different conditions from his neighbor. **Target grouping** helps to strike a balance between two extreme alternatives:

(a) the impossible task of developing recommendations for each farmer and
(b) the inappropriate one of developing one recommendation for the whole farming community despite differences in farming systems, determining goals and circumstances.

"Target grouping", as it is described in Chapter 6.1.3, considers both the questions of **"where"** the innovation is demanded and **"who"** is demanding. Target grouping divides the heterogeneous farming population into more homogeneous subgroups on the basis of those factors which determine farming systems (i.e. to natural and socio-economic circumstances, goals and preferences, etc).

The target group "extension workers"

Researchers' immediate "target group" is usually **extension workers** where extension and research is not carried out by the same person or institution. The results eventually achieved are transferred first to extension workers, who in turn are expected to disseminate these results or to help farmers adjusting them to their own specific conditions.

Extension workers' and farmers' perception of the demand for technology are not always identical. The question whose perception of demand should carry more weight -that of farmers or that of extension workers- is a controversial one. To create a good working relationship between extension workers and researchers, which is required for an efficient dissemination of innovations, it may help if the demands expressed by extension workers is seriously taken into account. Though it may not improve farmers' practices immediately, it is necessary at times to address extension workers demands in order to create favourable conditions for the introduction of innovations.

What is demanded ?

This question forms the contents of practice-oriented research.

The term "demand", as it is applied here, refers to **problems** which are to be solved as well as to **opportunities** which could be utilized.

The most important **criterion** for the demand for innovation is that the **need is felt by the target group**. Farmers however may often not mention all the needs they feel due to social barriers between themselves and researchers – for prestige reasons or simply because of the strange interview situation. Particularly at the beginning of the research process farmers may only mention those matters which in their view correspond with researchers' expectations. Or farmers may expect researcher's interventions according to previous experience with development institutions.

Furthermore, **the target group itself may not beware of its demand for innovation** because they lack the necessary experience or knowledge. This applies to actual production problems, where perhaps **existence without a certain problem is beyond the farmer's experience** (for example, pest or disease problems, the absence of which is virtually unknown). It also applies to problems which **slowly develop** and are not yet really felt (i.e. environmental pollution in industrialized countries had a long time to develop before people started to consider it a problem; the same can usually be said of slow developing soil fertility problems). Awareness of demand requires, furthermore, a knowledge of the possible supply (you would not know, for example, that you need a stereo music system if you are unaware that such a system exists). Many opportunities are just not utilized, because they are not known (like the possibility of improving production with a new variety or a new crop).

Because the aim is for farmers to eventually express their demands themselves, researchers will have to assist them in the formation and articulation of their needs. Researchers' role at this stage will be:

- to clarify expectations with regard to the possible results of on-farm experimentation;
- to identify and show cases where the demand is already obvious;
- to show or develop examples (pilot technologies) which reveal the potential of those opportunities which are not yet utilized.

In order to achieve this, the researcher will have to develop his **own hypotheses** as to demands which are not yet perceived or experienced by the target group.

Where is the innovation demanded ?

This question focuses on the geographical distribution of the demand for innovations. It is important where the programme area is heterogeneous in terms of natural or socio-economical conditions and farming systems. Differences with regard to factors like soil, rainfall or marketing facilities can considerably influence the demand for innovation. On-farm research programmes should be actually run in those areas where the demand was identified.

Tools and methods

Where problem consciousness of farmers is not well developed yet, the exploration of demand may be initially based more on researchers' perception. As confidence between farmers and researchers improves and farmers' problem consciousness develops, the exploration of demand will be guided more by farmers' own opinions.

An useful procedure for the researcher to develop a hypothesis as to existing demand is shown in Figure 2.2. The analysis of **secondary information** is utilized to develop an working hypothesis. This is the basis for a

subsequent exploratory survey (a combination of individual interviews and group discussions with farmers, and field observations made by the researcher) and for the dialogue on innovation.

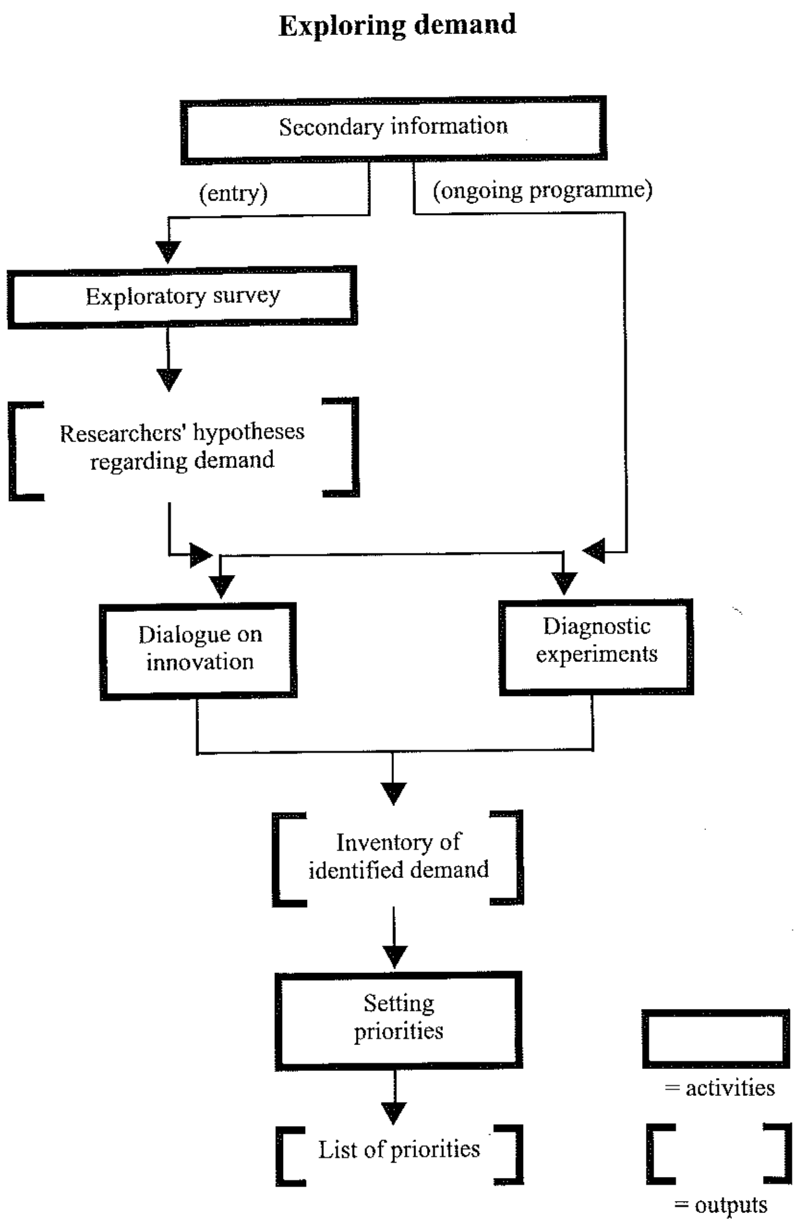
The **exploratory survey** is not a must. It can be, however, helpful at the beginning of a research process where problem consciousness and problem solving capacity of the target population is not well developed yet. The exploratory survey (see Chapter 4.2.1) allows the researcher to develop his preliminary hypotheses with regard to the demand for technology. These hypotheses can in turn form the basis for more exploratory work (for example diagnostic experiments if interrelationships between production factors and productivity need to be clarified), for confirmatory studies (for example, a formal survey if decisions as to subsequent steps require quantitative validation of the hypothesis) or for a dialogue on innovation.

A **dialogue on innovation** (see Chapter 4.2.2) is the crucial element in the exploration of demand. It is the first really participatory element in the research process. Farmers are the "subjects" of the research. They determine the course of action through their analysis of demand and their setting of priorities, whereas their role was more that of the "object" and informant of the researcher during the exploratory survey.

Reference is made to:

- Chapter 4.2.1 for the exploratory survey;
- Chapter 4.2.2 for the dialogue on innovation;
- Chapters 6.1.1 – 6.1.4 for analytical methods which are useful in the dialogue on innovation and can help to analyze information from exploratory surveys.

Figure 2.2: Tools and methods for the exploration of demand



2.4.2 Identifying alternatives

At this point the focus of subsequent experimentation should be determined. To simply hope for a lucky hit, as which researchers sometimes do, reduces the likelihood that the direction chosen for experimentation really contains the technology which could best meet the demands of the target group. The following, therefore, outlines a systematic approach to the identification of potential options so as to improve the chances of success.

"What's a good banana?" Farmers criteria play an important role in the identification of trial options

Purpose

"Identification of options" means to select according to **defined criteria** a set of **available technologies** which appear to be **appropriate to satisfy the identified demand**.

This stage defines the subject of the subsequent experimentation. As a basis for this, **criteria** are first to be determined which are used to assess which technology potentially meets the identified demand. The same criteria determined here are used later on throughout the subsequent stages to assess whether the selected technologies really met the demand.

The identification of **options** is an important interface with station-based research. Ideally it is expected that station-based research makes available required technologies as far as they are developed already, or develops these technologies if they are not yet available.

Activities and methods

The identification of potential options consists mainly of listing and screening available technologies. A possible procedure for this is shown in Figure 2.3.

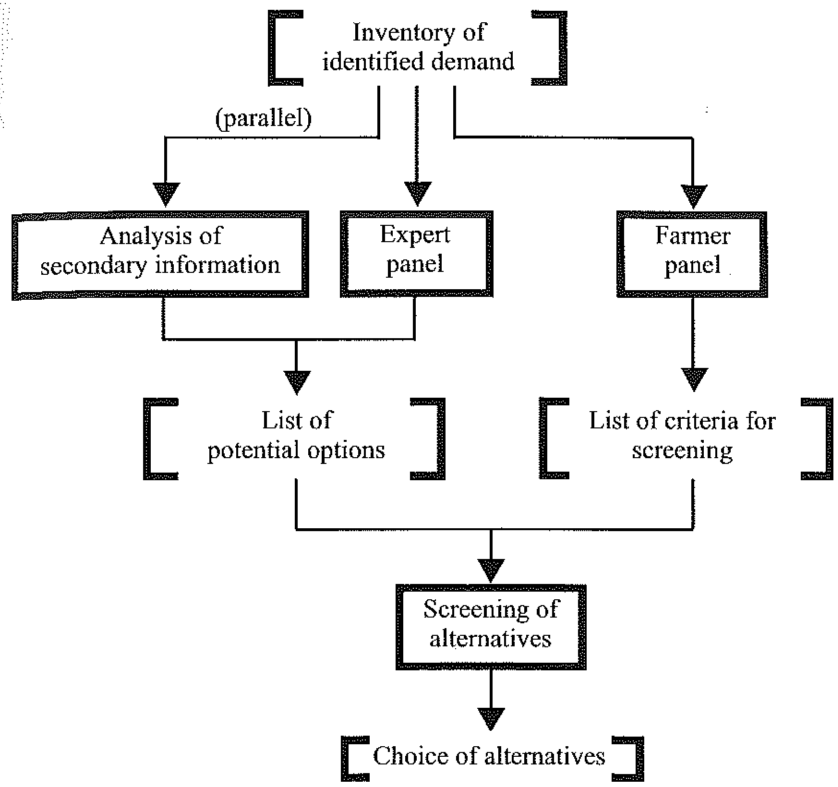
An essential step in the preparation stage is to analyze secondary information on the subjects determined by the exploration of demand. This can be written documentation of results from research stations within the area or research institutions working in a similar environment. Also direct communication with relevant station based researchers is absolutely necessary because not all the information available is documented.

In this context it is also important not to forget options already independently developed by farmers. Such information may already be available from the dialogue on innovation or the exploratory survey and researchers should be on the lookout for it.

Based on the information available, a list is made of options which potentially satisfy the identified demand. This list should be as broad as possible to ensure that no alternative what so ever is left out. The feasibility of the alternatives does not need to be considered now. It is, however, helpful to formulate the alternatives as precisely as possible in order to facilitate the logical deduction of treatments for the testing stage later on.

The list of alternatives can be drawn by the team conducting the on-farm research. Better results are achieved if an "expert panel" is employed, comprising the on-farm research team, appropriate farmers, relevant station-based researchers and extension workers.

Figure 2.3: Proposed procedure for identifying options



The same panel can also draw up criteria for screening the alternatives. However, a more appropriate team of experts to define criteria for screening would be a discussion panel consisting purely of farmers.

Criteria for screening

The listed alternatives are systematically screened through a set of defined criteria in order to avoid an arbitrary selection of technologies for testing.

These criteria describe a number of essential qualities an innovation should have in order to meet the identified demand.

Table 2.4 gives an example of possible criteria for screening categorized under five subheadings:

- feasibility under given socio-economic circumstances;
- correspondence with farmer' goals and preferences;
- feasibility under given natural conditions;
- ecological viability;
- economic viability.

Table 2.4: List of criteria for screening of alternative technologies

(1) Feasibility under given socio-economic circumstances
- correspondence with farmers' skills;
- availability of input and produce markets;
- sufficiency of farmers' resources;
- sufficiency of research resources.

(2) Correspondence with farmers' goals and preferences
- correspondence with food/taste preferences;
- compatibility with cropping pattern/cropping calendar;
- interaction crop / livestock.

(3) Feasibility under given natural conditions
- expected production as compared to present situation;
- expected stability of production;
- expected production risks.

(4) Ecological viability
- expected effects on the natural environment;
- expected effects on the long term productivity;
- expected effects on diversity of agro-ecosystems.

(5) Economic viability
- profitability as compared to present situation;
- expected effects on produce markets.

(6) Further criteria

Though these subheadings may be universally applicable, the individual criteria and their significance will depend on the respective subject. For every subject determined in the "exploration of demand", a new list of screening criteria will have to be developed.

Reference is made to:

- Chapter 6.1.5 for analytical approaches to screening

2.4.3 Testing alternatives

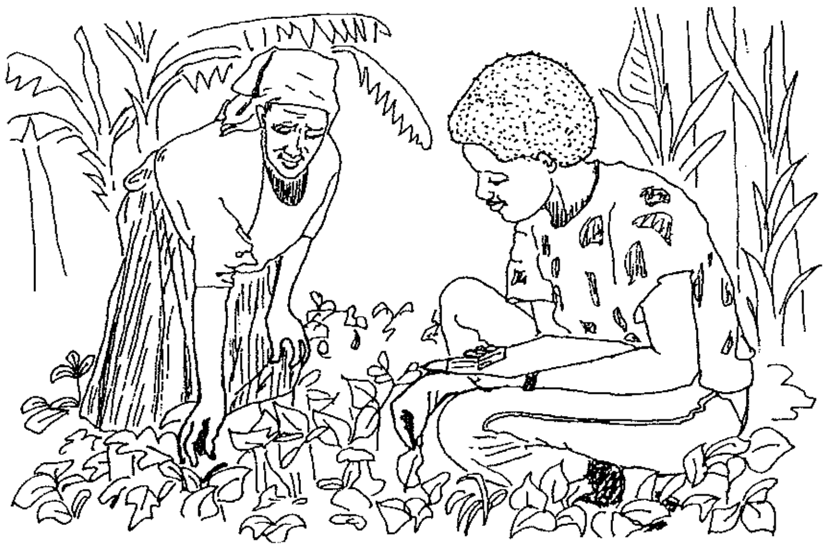
The testing of alternatives is one, but not the only important component for the development of appropriate innovations. The most excellent experimentation will not cover up a superficial preparation or analysis. The testing of alternatives is also not implemented as an end in itself but as a basis for the collection of information. This information is of agronomic as well as of socio-economic nature, as it will be shown in the following.

Purpose

The purpose of this stage is to
- **plan and execute experiments** which are used as a basis for
- **collecting the data** required to examine how far the tested technologies comply with the criteria defined earlier.

The nature of the data to be collected should have basically been determined already when the criteria for the identification of appropriate alternatives were defined.

They cover:
- the feasibility of a tested technology under the given socio-economic circumstances;
- the correspondence with farmers' goals and preferences;
- the feasibility in to the local environment;
- the ecological viability, and
- the economic viability.



"What's happening in our trial?" There is a lot researchers can learn from farmers during experimentation

Agronomic data, which are often the center of attention, are important for assessing the suitability of a technology to the local environment. They are also an important basis for determining economic viability. Agronomic data are not, however, the only important data. **Equally important is also socio-economic** data on how feasible an innovation is likely to be under the given circumstances and on its correspondence with farmers' goals and preferences. Gathering socio-economic data sometimes requires even more effort if agronomic data are available already from station research.

Furthermore, it is also helpful to examine how far the tested technologies are taken over by participating farmers. Farmers themselves are in the best position to judge whether a new technology really meets actual demand. Nevertheless it has often been observed that shortcomings of a technology do not come to light through dialogue with farmers. The examination of adoption by farmers is, therefore, a valuable indicator of the appropriateness of an innovation and, where necessary, a good starting point for a dialogue about its shortcomings.

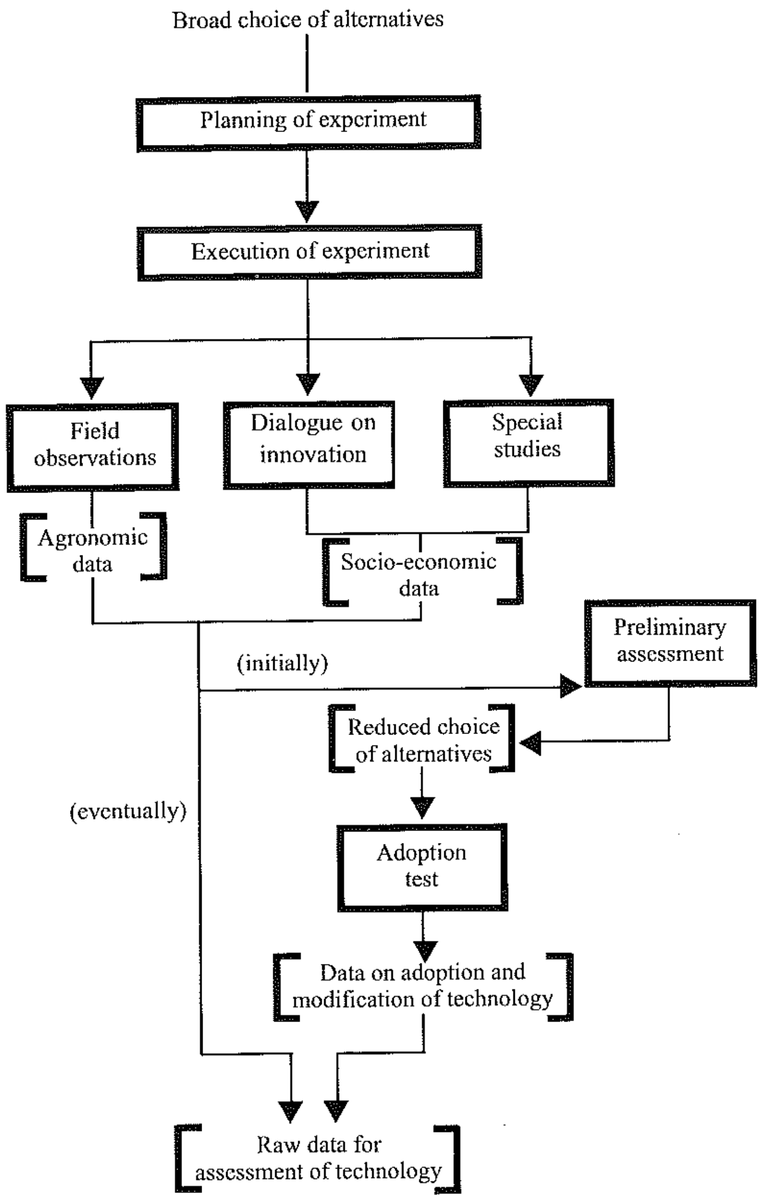
Procedures and methods

What has been stated concerning the overall process of on-farm research applies in particular to the testing stage: there are no "strict rules" which are universally applicable. Instead, the guiding principles given here rather need to be adapted to the specific situation of a project and the question to be answered by the experiment.

In any case, the testing stage should start with the **planning of experiments**. This includes the definition of **objectives** and, closely related, of relevant **data to be collected**. This process is, by and large, a translation of the screening criteria which were drawn up during the identification of options. Furthermore, the alternatives identified are transformed into experimental **treatments**. Also decisions are made at this stage concerning the **arrangement of treatments** (or the trial design), **suitable experimental sites** and **appropriate management**.

Experiments executed in the field form the basis for collecting data needed to confirm whether the alternatives being tested comply with the defined criteria. Different criteria require different **types of data** and, accordingly, different **methods of data collection**.

Figure 2.4: Possible sequence of data collection



Assessing a technology's suitability to the local environment and its economic viability mainly requires agronomic data. This information comprises measurements and observations collected in the trial field.

The correspondence of a technology with farmers' goals and preferences is largely assessed by farmers themselves. Relevant information is collected in a "dialogue on innovation" with farmers. Farmers' participation in the assessment of a trial technology takes place at this stage. Specific studies or secondary information analysis may be required if further socio-economic data is needed (for example on price fluctuations, market structures etc) .

The **adoption or non-adoption** of an innovation by participating farmers gives the ultimate answer to the question of whether a trial technology complies with the required conditions in the view of farmers. Relevant data can be, for example, collected in a formal survey combining interviews with farmers and field observations in the season after the trial. The survey may also tackle the question of whether farmers modified the trial technologies in order to better adapt them to their specific situation.

Not all experiments will require the collection of all **types of data**. The data to be collected and the **sequence of activities** largely depends on the objectives of the experiment and the information already available. A possible sequence of activities is proposed in Figure 2.4.

Sequence of data collection

The early literature on on-farm research commonly suggested a defined **sequence of data collection**: agronomic data were the focus of attention in the first seasons of an experiment. Agronomic criteria were used to narrow down the choice of alternatives. Farmers' responses and other socio-economic factors were analyzed only with regard to a limited choice of alternatives.

Experience has shown, however, that agronomic criteria applied by researchers frequently deviate from those criteria important to farmers. As a result, the agronomically "best" technologies are often rejected by farmers. "Second best" alternatives however, corresponding better with farmers' goals and preferences, had already been dropped from experiments by the time farmers were asked for their opinions.

A widespread conviction among on-farm research practitioners is, therefore, that **farmers should participate in the assessment of the trial technologies as early as possible**. Instead of following a fixed sequence with regard to the types of data collected, the data collection should be guided by the actual requirements of the experiment. This means, the data collection procedures should be individually tailored for every experiment (and, in fact, the design of an experiment may require adaptations to the data to be collected in the course of the experimentation). The **guiding principle** could be the question for the **most critical factor**(s) determining the adoption of a specific technology by farmers. Depending on the answer, the focus of data collection can either be first on socio-economic or on agronomic data or both can be collected simultaneously on a similar scale.

The only logical order of procedure is to first collect in-depth socio-economic and agronomic information for a larger choice of alternatives on a limited scale. Thereafter more superficial data on adoption are collected for a narrower choice of the most promising alternatives on a broader scale. Good socio-economic data, in particular information related to farmers perception, require as much attention as the collection of agronomic data. Experiments in this respect can be made, therefore, only on a relatively few farms. On the other hand, a relatively large number of representative farmers is eventually required to asses adoption or to monitor which modifications to the technology are made by farmers.

Reference is made to

- Chapters 5.1. and 5.2 for planning of experiments;
- Chapter 5.3 for the implementation of experiments;
- Chapter 4.2.2 for the dialogue on innovation;
- Chapter 4.2.3 for the implementation of surveys to analyze adoption.

2.4.4 Assessing tested alternatives

A new technology is often judged to be appropriate based exclusively on its productivity as determined in the experiment. As a consequence, many new technologies are not taken over by farmers because they do not comply with their goals and preferences or the circumstances they face. In the following, therefore, a more comprehensive approach to the assessment of a new technology will be described.

Purpose

The assessment of options is basically a desk job for the on-farm research personnel. It synthesizes all the collected data and the opinions already collected from farmers in the previous step in order to determine which of the tested alternatives are most appropriate for the given set of conditions, with reference to the following criteria:

- feasibility under the given socio-economic circumstances;
- correspondence with farmers' goals and preferences;
- feasibility in the local environment;
- ecological viability;
- economic viability and
- adoption by the target group (this is the ultimate indicator, i.e. that the farmers themselves consider a technology to meet the actual demand.

"What is the best – and why?" Farmer's assesment decides about the success

The results of the assessment determines further action:

Only a technology which complies with all the defined conditions is ready for dissemination.

The research cycle is re-initiated,

- if none of the options tested meets all the conditions,
- if the required data are not complete or
- if there are still doubts with regard to the appropriateness of the options.

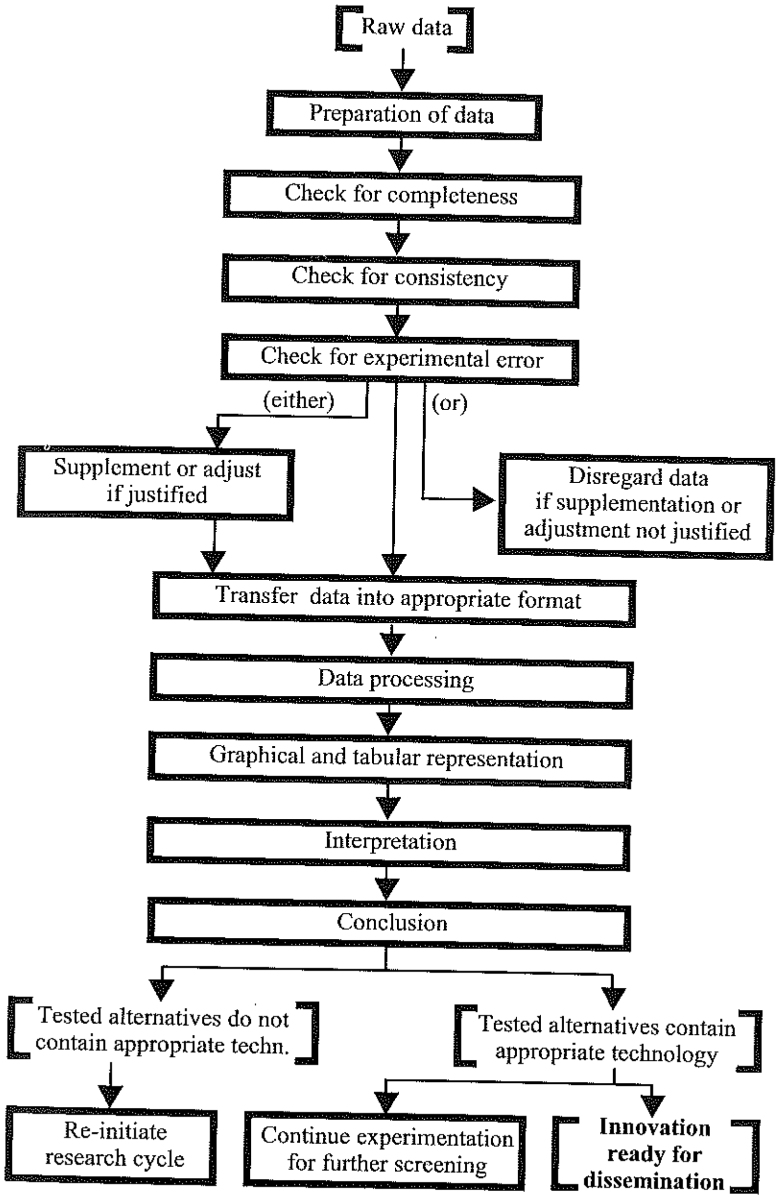
Procedure and methods

A suggested procedure for assessing the trial technologies is shown in Figure 2.5.

Preparation of the raw data for analysis is the first and often most time consuming step. To a large extent it determines the quality of the final result. It involves checking for completeness, for experimental errors and for data consistency as well as transforming of data into a format appropriate for processing.

Incomplete data must be supplemented and incorrect or inconsistent data adjusted as far as it is possible and justified. Data sets where supplementing or adjusting is not possible or practical, are disregarded from further processing. The remaining data sets should be arranged in a format appropriate for further processing. This is important in particular where computer facilities are utilized for data processing.

Figure 2.5: Proposed procedure for analyzing on-farm trials



The data are processed using appropriate statistical procedures. **Tabular and graphical representation** of the results simplifies their **interpretation. Conclusions** are to be drawn regarding whether any of the trial technologies complies with the defined conditions. The conclusions determine further action, for example whether

- to **continue the experimentation** to collect further data. This can be the case if the available data do not appear to be conclusive. As was mentioned earlier, not all data considered necessary may be collected simultaneously but stepwise, the most critical ones first. In this case the decision to be taken is whether the data already available justify a continuation of the experiment;
- to **re-initiate the research cycle** if none of the tested alternatives meet all the defined criteria;
- to **disseminate the results** if one or more of the trial technologies meet all the defined criteria. If more than one technology tested in an experiment meet all the set conditions it would be worthwhile to not only promote what is considered the best technology by the researchers but a choice of alternatives to submit to farmers' own judgement.

Reference is made to

- Chapter 6.1.6 for the qualitative assessment of treatments by farmers;
- Chapter 6.2.1 for preparation, supplementation and adjustment of data;
- Chapters 6.2.2.1 for the statistical and 6.2.2.2 for the economic analysis of experimental data;
- Chapter 6.2.2.3 for the analysis of farmers assessment.

2.4.5 Disseminating innovations

The on-farm research process described is not implemented for the sake of publishing results but in order to make better agricultural technology available to farmers. The mere publication of an annual report will usually not suffice to achieve this goal. The dissemination of results requires as much attention as the other stages in order to ensure that developed technology really reaches its target group.

"What's new?" Creating awareness is an important task of extension workers

Different approaches to research require different procedures with regard to the dissemination of research results. Two principal approaches are differentiated:

I Research and extension are carried out by different persons or organizations

The immediate target group of researchers for the dissemination of results is extension workers, **where extension and on-farm research are not done by the same persons or institutions**. In this case it is the responsibility of the researcher to spread knowledge about innovation amongst extension workers.

It is recommended that decisions about which innovation to be disseminated to farmers should be made by extension workers rather than by researchers. This increases the chance that chosen innovations are promoted with conviction. The role of researchers at this stage should rather be

- to ensure that the results of research are made available to the extension workers concerned,
- to make the results understandable to extension workers and
- to advise extension workers with regard to their decision about the appropriate choice of technology.

Extension workers should be involved in the development of new technologies as early as possible to ensure that they promote the final choice of innovations with conviction. Suggestions for achieving an effective dissemination of results include:

- the participation of extension workers in exploring the demand for innovation, the identification of available options and the assessment of tested options;
- field days or field tours to familiarize extension workers with the ongoing programme and to keep them informed on progress;
- regular meetings and/or workshops to present and discuss results and, if possible, to draw conclusions with regard to their impact on the extension contents;
- distribution of written results; a presentation in bite-sized pieces, for example in the form of a regular newsletter or subject-specific paper is more easily digested than a comprehensive annual report;
- initiation of or participation in the preparation of extension materials.

II On-farm research is part and parcel of the extension work

In many extension and rural development programmes the development of innovations through on-farm research is part and parcel of the extension workers job. **On-farm research and extension are carried out by the same person.**

In this case one task can be the dissemination of locally realized outcomes of experimentation from those farmers participating in the on-farm research to those not actively involved. Another important task can be to spread ideas and experiences about how farmers can experiment with potential innovations by themselves.

Possible activities at this stage include (adapted from ILEIA, 1992):
- field days or field tours including farmers not participating in on-farm research to spread ideas within a village;
- cross visits from village to village in order to share ideas and experiences;
- field workshops with farmers;
- "farmer-to-farmer-learning-by-doing-training";
- developing written or audiovisual materials for farmers.

Reference is made to

- Chapter 3 for principles of communication with target groups.

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Part II The Tools

Chapter 3 Communication with farmers*

* This chapter is adapted from **Ashby, J. A. 1990.**: Evaluating technology with farmers. IPRA/CIAT, Cali, Colombia

Chapter 3 Communication with farmers

3.1 Factors determining the relationship between farmers and researchers

It requires more than technical skills if a researcher wants to involve farmers effectively in the development of innovations. Good collaboration requires mutual trust which stands or falls with the communicational skills of the researcher. These are to some extent a matter of natural gift, but some important techniques can be learned. In the following, a few tips and hints for getting in touch and communicating with farmers in a dialogue on innovation will be given.

Talking to researchers – a special situation for farmers

When farmers are talking to researchers or extension agents, they are often acutely conscious of being in a very special social situation. The researcher will usually be more educated than the farmer and often uses different words or scientific terms which the farmer is unfamiliar with. Differences will be visible in dress. Often farmer and researcher are from different cultural or ethnic groups and may even speak different languages. All these differences are obvious to farmers, making them aware of being in a social situation they are unaccustomed to, and putting them on their guard about what they say or do. As a result, it is rather common that farmers do not express what they really feel or think in the conversation with the researcher.

Farmers are guided by

- **expectations:** researchers (or extension workers) are often seen as people who have access to knowledge, techniques or inputs which can be valuable to farmers. They may, therefore, be in the position to bring improvements from outside. While such expectations may create a healthy motivation for farmers to participate in on-farm research, they can also create reserve, because the farmer does not want to offend the visitor.
- **suspicion**: farmers are often suspicious of the researchers real motives. Why should a stranger be interested in helping farmers?

Bad experience with outsiders in the past can intensify suspicion. Suspicion can be particularly intense when farmers and researchers are from different ethnic, religious or social groups that have been in conflict in the past.
- **deference**: farmers may perceive researchers as socially superior, because of their status as a government official, their better education, etc. This feeling will be the stronger the more rigid the social or political order. Subconsciously researchers may share and even reinforce the deferential relationship. In such a situation farmers have the tendency to look for clues about what the researcher is thinking and to defer to what they believe to be the views of the researcher.
- **courtesy**: even if farmers are not guided by their expectations, by suspicion or deference, farmers may be reluctant to disappoint the researcher by pointing out a flaw in the technology.

Researchers' tasks

The goal is not achieved if farmers express their approval of a potential innovation because of fear or suspicion, deference, or politeness, but only if the innovation really meets farmers needs. One of the most difficult tasks of the researcher is to **encourage farmers to express frankly their own views.**

It is therefore necessary to **clarify expectations** and to **reduce suspicion** or fear. It also means **not imposing own views** on farmers, consciously or unconsciously.

The necessary trust of farmers does not occur spontaneously. It needs **careful nurturing** throughout the entire research process and often takes years to develop.

3.2 Establishing a collegiate working relationship with farmers

Successful on-farm research requires that farmers frankly express their opinions about the technology which researchers and farmers are testing together, and are willing to discuss the reasoning behind those opinions. The essential ingredient of success is a high degree of trust and confidence between the researcher and farmer. This means that each party feels sure he understands the other's motives, what the other stands to gain from cooperating, and what the other expects (and does not expect) from him.

Establishing such mutual understanding involves a social interaction between the researcher and the farmer in which many spoken and unspoken signals are exchanged, as in any face-to-face communication between people. The researcher's awareness of these signals, and his skills in consciously managing them, will determine the success of the evaluation. In this section, we review the techniques which researchers need to exercise in order to achieve successful communication with farmers.

"Entry" or managing first impressions

The term "entry" refers to the procedures used for gaining acceptance in the farming community for the initial presence of the on-farm research team, and for establishing an understanding among community members of what the research is about. Even when farmers are totally accustomed to the frequent presence of outsiders whose main activity is to ask them questions, the initial activities of the on-farm researcher create first impressions which may be beneficial or prejudicial to the success of interaction with farmers later on.

When the on-farm researcher or team begins field work in a farm community, their actions will stimulate curiosity and speculation ranging from mild to intense. Farmers will ask themselves questions such as:

"What do they really want to find out from us?"
"How might they bring harm to or benefit us?"

It is important to be aware that first impressions and the way in which farmers discuss and answer such questions among themselves can influence the ease or difficulty with which relationships of mutual trust and confidence are established. Therefore, the presentation of the researchers' objectives needs to be carefully structured from the very start.

As discussed in the preceding section, the researcher is likely to encounter several possible expectations on the part of farmers involved in the research. The farmer may define the social situation in which he is being asked to take part in some or all of the ways illustrated in Table 3.1.

Table 3.1.: Conventional expectations of farmer-researcher relations

Definition of researcher's role	Definition of farmer's role
Researcher is the expert.	Farmer is the layman.
Researcher is a social superior.	Farmer is a social inferior.
Researcher represents modern agriculture.	Farmer represents backward traditional agriculture.
Researcher merits deference from farmers.	Farmer should show deference to researcher.
Researcher asks questions.	Farmer gives answers.
Researcher makes decisions.	Farmer complies with researcher's decisions.
Researcher controls strategic resources, may harm farmer, i.e. act counter to farmer's interests.	Farmer lacks control, is powerless to influence researcher's behaviour, is dependent on researcher's goodwill.
Researcher is supposed to teach and convince the farmer that the new technology is better than existing practices.	Farmer is supposed to learn from received wisdom of researcher.

These expectations are possible sources of bias which are likely to discourage farmers from giving researchers frank opinions. They may also motivate farmers to distort the information they give to researchers. The researchers basic objective must be therefore the elimination of these expectations. He must recast them and try instead to build the expectations summarized in Table 3.2.

Table 3.2: Key expectations for successful farmer evaluation

- Researchers and farmers are experts in their own knowledge and experience.
- Both types of knowledge merit mutual respect.
- The farmer`s agricultural practices and whole way of life are respected and esteemed by the researcher.
- The farmer needs to understand the technology that is being tested and therefore has the right to ask questions; he is entitled to explanations and justification of the research.
- The researcher is motivated to learn from the farmer who therefore teaches as well as learns.
- The farmer will be responsible for decisions that can make or break the success of the research.

This brings us to an important principle for achieving successful on-farm research: it is essential **not to think of farmers as passive informants** in the research process. The farmer who is treated as passive informant is not very likely to take an active interest in the research, or to make an effort to formulate opinions about the technology. He is very likely, though, to give answers that he guesses are what the person asking questions wants to hear. The success of an evaluation depends, therefore, on creating a social relationship in which **the researcher and the farmer are both active participants** in research, questioning, studying, and arriving at conclusions together. The first step in creating this type of understanding is at the point of entry, when it is critical to explain thoroughly the objectives of the research, and to entertain questions and discussion about these objectives and what they imply in terms of farmer participation.

Clarifying expectations

A good social understanding between farmers and researchers is not enough to ensure effective participation of farmers in the on-farm research. Farmers must also understand well what is being studied. If farmers don`t know or understand the research objectives, their assessment will be superficial and misleading. To prevent this from happening, it is useful to arrive at the field site for the first time prepared to volunteer the following types of information:

- Your name.
- Your professional role (a simple job description).
- Your institutional affiliation (explain what the organization is called and what its main activities are).
- Reasons why researchers want to work on farms.
- Reasons why researchers need to talk with farmers.
- An explanation of what an experiment is, what is done, and for what purposes.
- An explanation of the role farmers will play in the research.
- Reasons why the farmer`s role is important (how research will succeed or fail depending on whether farmers take part).
- An explanation of what farmers can hope to gain (and cannot expect to gain) from taking part.
- An explanation of what researchers cannot do (provide rural electrification, install schools, etc.).
- An explanation of your special interests and expertise (related to specific crops, disease, etc.), and of these types of information you are interested in.

Figure 3.1 summarizes these topics in the form of a flowchart. The development of a flowchart is a useful technique for planning and carrying out an open-end dialogue with farmers on any number of topics. Use of a flowchart helps to structure communication with farmers on any number of topics. Use of a flowchart helps to structure communication with farmers towards a particular objective without imposing the rigidity of a questionnaire. Researchers can refer to a flowchart during discussion with individuals or groups of farmers to check that essential topics have been covered, and that particular points of importance have not been forgotten.

In the example in Figure 3.1 the dialogue is divided into three stages: warm-up, development, and the closure.

In the opening stage, the **warm-up**, the key expectations summarized earlier in Table 3.2 are defined by the researcher's presentation of him or herself.

In the second or **development stage** of the interview, the researcher develops two general themes:

1) The general purpose of the contacts being made with farmers;

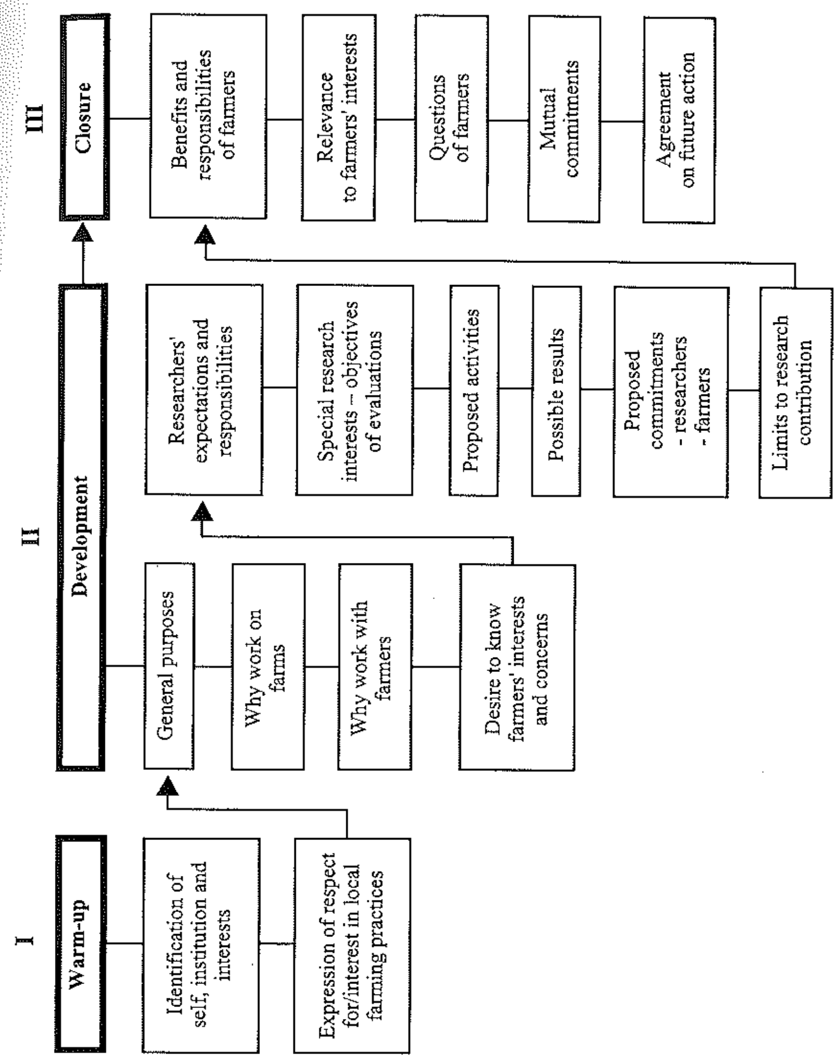
2) The expectations the researcher brings to the proposed relationship with the farmer, and the responsibilities of both sides involved in taking part in the proposed activities.

Finally in the **closure stage**, the researcher aims to verify that effective communication has been achieved concerning:

1) What the farmer can hope to gain from taking part in the programme (inviting questions to clarify the farmer's perceptions);

2) Agreement on mutual commitments and future action.

Figure 3.1: A flowchart of a dialogue with farmers for explaining the purpose of farmer evaluation



Several techniques for managing this open-ended style of communication with farmers will be treated in detail in the later section on face-to-face communication skills. Others are basic principles of conduct which influence first impressions and the effectiveness of dialogue with farmers. These are briefly discussed below.

Treating the farmer as an expert

Farmers are asked to participate in on-farm research to mobilize their farming systems expertise. While it goes without saying that not all farmers have the same level of competence in local farming practises, the researcher must treat each farmer as an expert. This is an important principle for laying the basis for a good working relationship with farmers. Therefore, it is extremely worthwhile for on-farm workers to communicate in initial contacts their intent to learn from the farmers.

A verbal explanation of why researchers want to learn from farmers is important, but not always convincing to a farmer who is accustomed to feeling deferential or suspicious towards official visitors. Therefore, the researcher should **communicate non-verbally** the value he places on a farmer's experience and wisdom, by asking the farmers to teach and explain some local practice or techniques which will be relevant to the proposed activities.

Such teaching can be done by individual farmers or by a group of farmers. It can focus on the use of traditional tools, planting methods, management practices (such as weeding), or harvesting methods, depending on the stage in the local crop season in which contacts with farmers are being initiated. For example, researchers who have never practiced farming as small farmers might ask for instruction on the use of traditional tools. Upon receiving such instruction, they will probably be surprised at how difficult it can be to manipulate the local tools expertly. Yet showing incompetence in such a situation, where the farmer is the expert, is constructive rather than damaging to the working relationship needed for conducting effective on-farm research: it will reinforce the message made verbally by the researcher, that local farmers will bring unique expertise to bear on development of innovation. The researcher, by getting his hands dirty in such a situation, sends the non-verbal message that local farming practices are worthy of respect, a message which is especially important in cultures where low status is associated with manual work.

Treating the farmer as an expert also involves **showing respect for the farmers time**, for local hospitality and social customs. Effective interaction will not be achieved if the farmer is in a hurry to get on to some other pressing task while the on-farm worker is trying to explain a proposed trial or conduct an assessment interview. Therefore, at any of the points of contact with farmers discussed in this handbook, it is essential to ask the farmer if he has time for the proposed activity. The appropriate response to any sign of hesitation on the part of the farmer is to request the farmer to suggest another more convenient time.

Equally, time spent in accepting hospitality and chatting on topics unrelated to evaluations is time well spent because it communicates non-verbally a respect for, and interest in, the farmer as a person, which is indispensable to a good working relationship.

Although these principles of field work are usually well-known and appreciated by experienced field staff, it is essential for researchers managing a large number of evaluations to plan to allocate tasks with such considerations in mind, especially in the early stages of contact with farmers. The benefits of doing this are unquestionable. Placing the farmer in a teaching role is an extremely powerful technique for restructuring the conventional expectations of researcher-farmer relationships outlined in Table 3.1, and for subsequently working towards achieving those expectations essential for successful farmer evaluations. And it is especially useful for the dialogue on innovation, because it provides the researcher with the local agricultural terminology, which is indispensable for understanding farmer's concepts. In addition, it communicates the on-farm worker's respect for, and intent to learn from a farmer's knowledge. It also gives researchers the opportunity to assess how articulate different farmers are, as they explain how and why local practices are followed. This is an important criterion for selecting the farmers in some stages of the on-farm experimentation (see Chapter 5.3.1).

3.3 Communicational skills for assessing technologies through dialogue with farmers

Nothing seems more natural or straightforward than for an agricultural researcher or extension agent to talk with a farmer, especially because the topic of conversation is likely to be of profound interest to both. Yet because of the social dynamics of a dialogue on innovation between researchers and farmers in developing countries discussed earlier, the skills required for effective communication with farmers are quite different from those which come naturally in everyday conversation. For this reason, a dialogue for assessing potential innovations is different from a conversation with farmers.

The open-ended farmer interview in the dialogue on innovation is also a different mode of communication from a survey interview. The survey questionnaire might seek opinions which researchers should be able to predict. In contrast the open-ended dialogue explores what farmers think about the technology being tested. The answers are spontaneous, and not readily predictable. The information researchers will obtain from farmers in the dialogue on innovation is not known until a number of interviews have been completed. This is precisely the purpose of the dialogue: to bring to light the farmers' criteria, which would otherwise be unknown. Some of the most valuable information from dialogue on innovation with farmers can best be obtained trough the proper use of open-ended questions, a technique quite different from the closed questions that are typical of a formal questionnaire. For this reasons, knowledge of how to manage the skills of face-to-face communication is invaluable for an effective dialogue with farmers.

We can divide the face-to-face communication skills useful for the dialogue on innovation into two types of techniques: those for listening, and those for asking questions. **How you listen** to what the farmer says is as important as **what you ask** the farmer. In a well-conducted dialogue with farmers, the researcher should listen more than he or she talks. This by no means implies that the researcher is passive. On the contrary, the researcher must constantly be alert of the need and opportunity to be directive, steering the flow of farmers' comments so that reasoning is clarified and information is gathered which makes sense to the researcher, and can be made intelligible to his or her colleagues. The communication skills discussed here are unobtrusive methods for directing open-ended interviews with farmers so as to achieve an effective dialogue on innovation.

How to listen in a dialogue on innovation

If you could take ten or fifteen minutes to eavesdrop on a conversation between researcher or extension agent (R) and a farmer (F) in the culture in which you plan to conduct farmer evaluations, you might see and hear any of the following:

R agrees with F and interrupts him to give an example of something that supports his point of view.

R contradicts F.

R shows disapproval by vigorously shaking his head, by facial expression or by moving away from F.

R is bored by F, stares into the distance, fiddles with his clothing, picks his fingernails.

F shows R how to do something and R gives F advice on how to do it differently.

R loses interest in what F is saying and introduces a new, unrelated topic of conversation.

R expands on a theme F and overrides F's attempts to speak.

In a discussion about agriculture between a researcher or extension agent and a farmer, these everyday events are very likely to occur because researchers and extension workers have been trained to give farmers advice to improve on what they normally do. Yet each of these normal conversational behaviors is inadmissible and counterproductive to a dialogue on innovation. In contrast to a conversation, the dialogue on innovation requires the researcher or extension agent to be receptive to whatever the farmer says, however contrary to received wisdom this may seem to be. It requires him to use **listening skills** to help the farmer articulate the reasoning that underlies the point of view that he or she is expressing.

Basic skills for listening to farmers will help the researcher to communicate verbally and non-verbally to the farmer that the researcher has a sympathetic and lively interest in the farmer's comments about the technology they are testing together. A useful exercise in this respect is to jot down on a piece of paper, for yourself, the culturally appropriate signals that you can make in a face-to-face conversation to express interest in what the speaker is saying. These might be for example:

- Nodding your head.
- Interpolating grunts that express interest ("uh-huh" and "umm" in English).
- Interpolating "I understand" or "very interesting".
- Leaning forward intently.
- Making eye contact.
- Smiling.
- Taking a relaxed body position.

The important "dont's" in effective listening are therefore:

- Don't get impatient or interrupt the farmer.
- Don't contradict the farmer.
- Don't show disapproval of the farmer's statements, even if you disagree.
- Don't express judgements about the correctness or incorrectness of what the farmer says.
- Don't give the farmer advice during an evaluation, even if your other professional responsibilities or activities involve giving farmers advice.
- Don't convey either verbally or non-verbally that you are bored by what the farmer is saying, even if his comments wander away from topics that are of interest to you.

Body language

It should be clear from making a list of culturally appropriate signals used by an interested listener, that many involve body language. How you position yourself physically in a dialogue with farmers is an important technique for communicating respect, a serious intent to learn, and deference to the farmer's opinions. With practice, such techniques become second nature to the interviewer.

For example, it is quite usual for the researcher, because of his social and cultural origins, to physically tower over the farmer. This, however, implies a researcher's superiority. It is much more tactful for instance, when interviewing in a farmer's plot where a crop is being examined, for the researcher to stoop or kneel while the farmer remains standing, so that discussion can be carried on with the researcher looking up towards instead of down at the farmer. If the dialogue takes place in a setting where it is possible to sit, guide the farmer to a situation where both or all participants in the interview can talk sitting down. Often in a household setting, farmers invite the researcher to sit while the farmer remains standing. Again, it is important to communicate that it matters to the researcher that the farmer should feel comfortable in the interview situation by ensuring that both are sitting.

Very often in a field setting, researcher and farmer stand sweating in the hot sun throughout the interview; consideration for the farmer's comfort can be shown by moving into the shade when practical. This communicates that the farmer's well-being is of concern to the researcher.

Another aspect of body language that can influence how the researcher communicates in an interview is the physical space. Research shows that people position themselves physically in different relations to each other depending on the type of social interaction they are involved in, and common sense tells us this is so. Different degrees of physical proximity are acceptable among close friends, among acquaintances, or among business associates. **Physical distance is a non-verbal way of communicating how much we trust someone**, and the degree of equality between us. How closely we are placed in relation to another person affects our tone of voice, our ability to receive and interpret facial expressions, and many other qualitative aspects of human communication.

It is quite normal in interviews for farmers to position themselves at whatever is culturally defined by them as a formal distance from the researcher, implying deference on their part. Part of the process of establishing relations of mutual confidence in an evaluation interview involves communicating to the farmer that **you, the researcher, wish to close the distance**. For this purpose, there is a useful technique which is integral to the farmer evaluation: have the farmer show you something – a tool, a disease-damaged leaf, an insect, a handful of soil, or whatever is appropriate in the context of the ongoing discussion – and close the physical distance between you in order to examine whatever is being shown. Alternatively, the researcher can take the initiative by picking up some item of interest and, while holding it, invite the farmer to come closer so that both can observe and comment on some aspect. This simple act redefines what is acceptable physical and social space between farmer and researcher, and qualitatively changes the communication that can occur.

Note-taking during the dialogue with farmers can be an important part of the researcher's repertoire of non-verbal behaviors that affirm serious interest in what the farmer is saying. Farmer's acceptance of note taking varies culturally, and it can be perceived as threatening. However, if the techniques for communicating with farmers discussed in this chapter have been followed, by the time the researcher carries out an assessment interview with a farmer, note-taking should be seen by the farmer as evidence of the value the researcher places on the farmer's ideas and comments about the technology they are testing together. The physical act of note-taking by the researcher therefore becomes a signal to the farmer that what is being said is important. Energetic note-taking emphasizes unobtrusively to the farmer that it is a significant topic, and this can be used deliberately by the researcher to get the farmer to expand on a point or to direct the farmer's flow of ideas while the researcher listens.

Body language can be quite different in different cultures. The important body language skills for face-to-face communication with farmer, involve identifying and practicing value-neutral body language which does not selectively support the interviewers' personal values, but encourages the farmer to speak freely.

From listening to questioning: probing

Probing is a technique which combines being a good listener with asking questions which direct the flow of a farmer's spontaneous comment. Probing enables the researcher to direct the flow of the farmer's comments unobtrusively by rephrasing or repeating in the form of a question something of particular interest that the farmer has said. This technique can be used in several different ways:

- Restate what the farmer has just said (the mirror technique):"so it resists the drought..."
- Repeat a remark that has just been made in the form of a question. By doing this, you invite the farmer to expand on this particular theme:"It resists drought?"
- Go back to and repeat a comment made earlier. This can help to steer the farmer's flow of comments in a direction you think important.
- Ask the farmer to clarify: "Could you tell me a bit more about this?"
- Summarize in your own words what you understand the farmer to have said, and ask:"Do I understand correctly?"
- Be prepared to admit uncertainty with the statement:"I'm not sure I understand correctly; you seem to be saying the following..." and repeat the farmer's statement.
- Remain silent (the five-second pause), keeping eye contact. This encourages the speaker to keep talking.

The "key-word" probe is a useful technique for checking your understanding of the farmer's point of view. This involves repeating a key word from what the farmer has just said and asking for clarification: "In what way is it resistant?" Probing is also important if you suspect the farmer is pulling your leg for some reason. It also serves for checking the consistency of a farmer's remarks.

Table 3.3: Key word probes for checking interpretation of what farmers say

Farmers' Comments	Key Word Probe
It's difficult to weed.	In what way is it difficult?
The sprawling plant is an advantage.	What makes it an advantage?
The flavour is better.	What is it about the flavour?
This is easier to grow.	How can you tell its easier?
The variety is too tall.	How does its being tall make a difference? What is "too tall"! – what would be tall enough?

Open questions

There are three main types of questions that the researcher could ask a farmer: leading questions, direct questions and open questions.

- **Leading questions** are a normal feature on everyday conversation. They imply the kind of response that is expected: the speaker may be trying, consciously or unconsciously, to get the listener to agree with or support the speaker's point of view. While leading questions come naturally in ordinary conversation, they do not belong in farmer evaluations.
- **Direct questions** are usually aimed at obtaining specific points of information. For example "How often does this crop association need to be weeded?" The dialogue on innovation is not the appropriate opportunity for direct questions to obtain this type of informationr(which can best be handled with a formal questionnaire) except when specific information is needed to clarify a farmer's opinion or judgement. For example:

  Farmer: "I hate handling this type of straw."
  Interviewer: "What type of straw do you usually use? And how is this different?"

Questions asking for specific points of information from the respondent are usually framed with words like: how; what; when; how many; how often; which.

- Asking **open questions**, however, is a key technique in the dialogue on innovation. They give the farmer free rein of expression without explicitly directing farmer's response. The researcher must, therefore, consciously repress and restrain his natural inclination to ask leading questions based on his personal opinions. He must instead monitor carefully how questions are posed, so that farmers express their own opinions.

Consider the following dialogue between a researcher and farmer who have entered a bean variety trial planted in the farmer's field

Researcher:	This looks very nice, some of these varieties appear to be doing really well, don't you think?
Farmer:	Yes, well, these are all good varieties.
Researcher:	What about this one, doesn't this look as if its standing up well against the mildew?
Farmer:	Yes, this is a healthy variety, very resistant.
Researcher:	What about the others, don't you think they are less resistant?
Farmer:	Well, I think most have suffered from disease; they look pretty sick to me.
Researcher:	Yes, this one in particular has problems, don't you agree?
Farmer:	This plant is very bushy, it has a lot of disease.
Researcher:	Don't you think some of these varieties are rather late flowering?
Farmer:	Some, like this one here, have not formed any pods yet; this is definitely very late.
Researcher:	Isn't this one rather stunted, maybe this variety needs more fertilizer.... What do you think?
Farmer:	Well, we have a lot of problems here with fertilizer; it is very expensive.

This dialogue is loaded with leading questions posed by the researcher like those which begin with the phrase "Don't you think...," or which convey the researcher's own opinions and receive an answer that confirms these. The problem with this style of communication is that it is unlikely to produce valid information about the farmer's true opinions. The researcher in this dialogue has given the farmer no opportunity to take the initiative in identifying what he or she sees as significant criteria for evaluating the trial.

In a dialogue with farmers to assess an experiment, even a question like "Which of the treatments in the trial do you like best?" contains the assumption that the farmer must like something in the trial. The appropriate

open question is better phrased as "What do you think of the treatments in this trial?"

Open questions most useful for the dialogue on innovation are those which stimulate the respondent to express and explain ideas and opinions. Such questions use phrases like: do you think; do you see; why do you believe.

Table 3.4: Open questions to stimulate farmers' ideas

• Can you tell me more about this?
• What would be an example of that?
• What makes you see it this way?
• What are some reasons for that?
• Could you help me to understand this better?
• Have you any other ideas about this?
• How do you feel about that?
• How do you think other farmers would feel about this?
• How would you describe this?

At an exploratory stage of the on-farm research, use of open questions like those in Table 3.4 which invite the farmer to articulate opinions and explain them is especially important.

It is useful therefore, for researchers involved in farmers' assessment of technology to develop a repertoire of questions such as the following:

- What do you think of the trial?
- Are there any treatments which you think are especially interesting? Why?
- Why do you think this difference (among treatments) has occurred?
- What do you think of the appearance of the plants?
- How do you think this treatment compares with that?
- Have you noticed any difference in the management (weeding/irrigation/fumigation, etc.) requirements?

- Why do you think this (referring to an observation made by the farmer) is important?
- What sort of yields do you think we are going to obtain?
- Do you think they are any problems here we should look into?
- Do you see any advantages or disadvantages to this (referring to an observation made by the farmer)?
- How do you think this compares with your current practice?
- What do you think of the time at which weeding (or any other operation) was done?
- If we plant this trial again next season, would you like to do anything differently? Would you like to suggest any changes?

In sum, the technique of dialogue with open questions relies on posing questions with words like:

- Why?
- What?
- How?
- When?
- Do you think?
- Do you see?
- Do you believe?
- What is your opinion?

Questions phrased in this way are open because:

- The researcher does not state his or her opinion in the question.
- The researcher does not imply that there is a "correct" answer to the question.

Establishing neutrality: balanced questions

One purpose of open questions is to show that the researcher is neutral about the preferences the farmer may have for any of the different treatments which the farmer is being asked to assess. It is extremely important to establish this neutrality at the outset of an evaluation so that, far from feeling that he should say what the researcher wants to hear, the farmer will feel confident that any positive or negative assessment is equally interesting to the researcher.

Often, at the beginning of a dialogue on innovation, the farmer may be noncommittal, aiming to be polite about the researchers' technology, and wondering about what he or she is expected to say. As a result, the open question "What do you think?" may at first elicit a polite response or vague generalities while the farmer stalls for time, hoping for leads which will indicate what opinions the researcher expects to hear. In this situation, the researcher can use the balanced question, which poses opposite points of view without indicating which one the researcher sympathizes with. For example:

Researcher: I' ve had several interesting discussions with local farmers about this planting system. Some say the plants are too close others say they could be planted even closer. What do you think?

or:

Researcher: I' ve heard a number of interesting opinions from farmers around here about this variety. Some say they like a bushy plant; others say the bushy plant is a problem. I' d like to understand this better. What' s your opinion?

Even though the questions in these examples are presenting the farmer with opinions, they can be useful starter questions in a farmer evaluation because they communicate to the farmer that (a) critical comments are valid and interesting to the researcher, and (b) there is no one "right" answer to the researcher' s question.

Other examples of balanced questions which can be used are:

- "Do you think this might require more or less labour/capital/fertilizer/irrigation etc. than what you presently use, or the same amount?"
- "How would you market this, or would you use the products mainly for home consumption?"
- "Would you recommend that we continue to test this, or had we better look for a different alternative?"

The disadvantage of the balanced question is that points for discussion are being introduced by the researcher. The farmer may not perceive planting distances or plant architecture, posed in the first two examples, as important. Therefore, questions which pose alternative opinions are primarily used to warm up the discussion, by reassuring the farmer that his or her point of view, be it positive or negative, is being sought. Once the farmer is confident enough to take the initiative in an evaluation, listening skills and probing combined with open questions are the appropriate techniques to use.

Summary of communication skills for assessing technology through dialogue

The face-to-face communication involved in an effective dialogue on innovation is quite different from every day conversation or just talking to farmers. In contrast to conversation or formal questionnaire, the open-ended evaluation interview involves the researcher in an exchange of ideas which requires him:

- to communicate respect for and lively interest in farmers ideas;
- to create an opportunity for farmers to express honest opinions;
- to elicit and understand the reasoning behind these opinion.

To achieve valid information about farmers opinion, the person conducting a farmer evaluation needs to consciously use skills for managing COMMUNICATION which include:

- **Listening skills**
  - to communicate receptivity and respect;
  - to hear what the farmer is saying with an open mind.
- **Body language**
  - to communicate respect, trust, and a collegiate relationship, a partnership;
  - to qualitatively improve communication by redefining physical space dictated by cultural norms when the researcher is a social superior to the farmer.
- **Probing**
  - to combine receptive listening with questions which unobtrusively direct the flow of a farmer's comments;
  - to check understanding of the farmer's point of view, and consistency of the farmer's remarks.
- **Open questions**
  - to stimulate free expression of farmers opinion;
  - to avoid giving clues about the researcher's own opinions, which may bias farmers response.

- **Balanced questions**
  - to establish the researcher's neutrality with respect to positive or negative comments;
  - to kick off and warm up the discussion, by reassuring the farmer that different points of view are sought, and that there is no "correct" answer.

Chapter 4 Data collection

Annex:

Chapter 4 Data collection

Data collection in on-farm research aims at the collection of those data which are considered necessary to solve a particular research problem. It is not done in order to establish a broad data bank.

Data can be collected for **different purposes**:

- for **exploratory purposes**, e.g. as a basis for:
  - a **description** of farming systems and practices,
  - **formulating hypotheses, theories and research questions** with regard to agricultural problems and potentials, or
  - **getting first ideas with regard to farmers' assessment** of potential innovations;
- for **confirmatory purposes**, as a basis for the **validation** of hypotheses and theories, or to answer a research question.

Data are differentiated according to their origin:
- **primary data** are new, genuine data generated in the course of the research;
- **secondary data** are already existing.

The following chapter will first describe some basic methods of data collection: secondary data collection, and primary data collection in non-standardized and standardized interviews, group discussions, the panel and observation and measurement. Each of these basic methods has its merits and its limitations. They are, therefore, hardly ever applied on their own. Nevertheless it is important to know their principles and characteristics in order to understand how each of them can be most appropriately applied in combination with other methods. Details as to their implementation are given in connection with the most common combinations applied in on-farm research, i.e. the exploratory survey (4.2.1), the dialogue on innovation (4.2.2) and the formal survey (4.2.3).

The experiment, which is explained at length in Chapter 4.3 is strictly speaking not a data collection method, but an important basis for the collection of data at several stages of the research process.

4.1 Basic methods of data collection

4.1.1 Secondary data collection

Secondary data collection deals with the gathering of already existing information. Appropriate utilization of this kind of information will ease the access to a research problem and economize the research process.

Purpose and application

Secondary data collection is useful at almost all stages of the on-farm research process:
- During the **exploration of demand** secondary data are the basic source of information on physical and socioeconomic conditions in the project area. They help to define preliminary target groups. They are the basis for the formulation of a first hypothesis on the need for innovation which is subsequently validated in field work. Where necessary, they are the basis for the selection of areas and farmers for primary data collection.
- Secondary data are the essential basis for the screening process in the identification of options for experimentation.
- Secondary data are important in many instances for the **assessment of options**. Long term rainfall data for example, have an important bearing on the suitability of a technology to the local environment; secondary data on market structures and prices are usually the basis for assessing economic viability ,etc.

Data sources

Various sources of information may be tapped. These can include maps, rainfall records, reports by government services, research stations, development projects, universities or NGO's. Written documents may be supplemented by verbal information from dealers, marketing organizations, extension agents, local leaders, missionaries, etc.

It should be kept in mind, however, that the aim is not to collect, but to utilize information. It is wise to carefully consider which information is worth considering at each stage of the research. A lot of information may be interesting but only some of it really useful.

4.1.2 Primary data collection

4.1.2.1 Interview

The interview is a type of data collection where people are asked to express their opinion on the subject to be studied. There are two types of interviews:
- the **non-standardized** interview and
- the **standardized** interview.

Characteristics

In **the non-standardized interview** the interviewer is only guided by a list of topics. The interviews are unstructured, informal conversations with emphasis on dialogue. The non-standardized interview allows a flexible reaction to the interview situation. Formulation of questions and their order is determined by the interviewer during the interview. The interviewer is free to dig deeper where it appears necessary and to add to the list of topics where it seems to be appropriate.

In the **standardized interview** the interviewer is working with a fixed questionnaire. Formulation of questions and their order is determined by the questionnaire. The questionnaire is presented to all interviewees in the same way. It is not supposed to be modified by the interviewer.

The relatively flexible **non-standardized interview** is considered the more suitable tool in the **context of discovery** (Phillips, 1968). It is useful for descriptive – explorative purposes (Hopf, 1991). The non-standardized interview is commonly considered an appropriate method for exploratory data collection to get first ideas in a field of work which is still fairly unknown to the researcher (Friedrichs, 1983). It is a good basis for the formulation of theories or hypotheses. The flexibility of the interviewer to adapt to the specific individuality of the interviewee also permits him/her to address sensitive issues (Berekoven e.a., 1989).

The **standardized interview** is more advantageous in the **context of validation** (Phillips, 1970). The use of a fixed questionnaire limits the range of topics that can be addressed. The formulation of the questionnaire therefore requires a previous good knowledge of the subject to be studied (Mangold, 1969) and a hypothesis or theory which is to be validated (Friedrichs, 1983). Standardization facilitates quantification and allows results to be reproduced and compared. The standardized interview has a particular

value as evidence, but it is less likely to generate "surprising information" or new ideas (Mangold, 1969). It is, therefore, considered the more appropriate tool for the collection of confirmatory data to prove the validity of theories or hypotheses or to answer specific research questions.

Application

The **non-standardized interview** is commonly applied in on-farm research for exploratory purposes. It is used in particular
- during the exploration of demand in **exploratory surveys**, to
  - get some ideas about farming systems and practices;
  - gather information about farmers' circumstances, goals and preferences;
  - formulate first hypotheses on how circumstances, goals and preferences determine farming systems and practices;
- for the identification of alternatives for experimentation in a **dialogue on innovation**, to
  - explore which criteria a new technology needs to satisfy farmers;
  - identify promising options from a set of available alternatives;
- for the assessment of technologies in a **dialogue on innovation**, to
  - gain information as to how far trial options correspond with farmers goals and preferences.

The **standardized interview** is less commonly applied at present in rural development projects, but it is a useful tool for the collection of data of a confirmatory nature. It is the basic tool of **formal surveys** and is applied, for example,
- in the final assessment of a technology to examine the degree of adoption or nature and extent of modifications by farmers;
- sometimes in the exploration of demand to verify a hypothesis which determines the direction of the subsequent research, if the validity of the hypothesis is not beyond doubt after informal data collection.

Problems of the interview situation

The interview situation causes a number of difficulties which influence the validity of the information obtained.

The extreme artificiality of the situation and the formality of an interview can result in an artificial reaction of the interviewee and in superficial answers. This is in particular the case in a formal interview situation.

Answers given are more often than not determined by social norms or of what the interviewee assumes to be the expectation of the interviewer rather than by the interviewee's own opinion. In the latter respect information obtained in an interview is biased in particular if the interviewee assigns the interviewer to a specific institution, ethnic group, social class etc. For example answers given with regard to agricultural questions are frequently guided by known extension recommendations rather than by a genuine opinion if the interviewer is identified as a member of an agricultural institution.

The information obtained is also influenced by the fact that the answers given in an interview are determined by the facts and goals the interviewee is immediately conscious of (very often one is not immediately conscious of everyday matters). The information given by an interviewee can furthermore reach only as far as his personal knowledge and experience (someone who does not know electric light will hence not be able to give a good description or assessment of it).

4.1.2.2 Group discussion

The group discussion is a specific type of **non-standardized** interview in which a specially arranged **group of people** discusses a particular subject under the guidance of the researcher or another person not belonging to the group.

Characteristics

The group discussion has many characteristics in common with the individual non-standardized interview: it is of an explorative nature, hence a tool to gain first or new idas about a topic. It hardly permits quantification of information and is, therefore, unsuitable as evidence.

The situation of the group discussion is, however, usually considered less artificial by the participants than the individual interview.

Inhibitions of the participants are often reduced in the course of the group discussion as the participants stimulate each other to express their views. One group discussion reveals usually more information than a number of individual interviews.

The group discussion can stimulate the opinion-formation process on subject, whereas the individual interview is dealing with already formed views. The opinion eventually expressed by the group does not really reveal individual opinions, because opinion formation is to a considerable extent determined by group dynamics. The group discussion does, therefore,

not assist in the quantification of individual opinions. Rather it provides insights into the **criteria and motives** determining the formation of an opinion and is an important tool for exploratory purposes in this respect.

Group discussions are not appropriate for socially sensitive issues (like income or food availability) and may produce misleading impressions if they are dominated by individuals.

Application

The group discussion is a useful tool during the **exploration of demand** to get the **exploratory survey** started off. It can provide a quick overview of farming systems and how they are determined by farmers' circumstances, goals and preferences. Thisis a good basis for the formulation of a topic guide for subsequent individual interviews.

The group discussion is also a valuable tool for a **dialogue on innovation** at all stages of the research process.

Importance of group composition

Interaction of farmers in a group discussion depends to a large extent on the composition of the group.

Heterogeneity in group composition can sometime be useful in obtaining a good cross section of opinion. The handling of heterogeneously composed groups requires, however, considerable moderator skills. Discussion within heterogeneous groups often provide invalid results because they are dominated by individuals or by members of specific social groups. In a village meeting or any other heterogeneously composed group for example, it is very likely that the discussion is dominated by men or by community leaders whereas women or community members with a lower social status remain silent.

Some **homogeneity** with regard to criteria like gender, social status, interest and experience with the subject to be discussed will usually be of advantage for group interaction. It can be helpful, therefore, to split up heterogeneously composed groups according to suitable criteria after some initial discussion.

Homogeneity can also be achieved if farmers are specifically selected for the purpose of a group discussion according to predefined criteria. In this case, a cross section of opinion requires the careful definition of all relevant groups of farmers and their separate involvement in group discussions.

Group interaction may be relatively easy in already existing groups of farmers. However, care is required as these groups are often not composed representatively for the purpose of the group discussion.

It is not an easy task for the researcher to achieve an appropriate group composition. Some criteria given in Chapter 6.1.3 (target grouping) may be useful in this respect. It is further recommended that local informants be involved in the definition of appropriate grouping criteria and the selection of suitable farmers for group discussions.

4.1.2.3 Panel method

The panel method is a specific interview method where the **same people** are **involved repeatedly** over a period of time. Such repetition is applicable to individual interviews as well as to group discussion. The basic principles described thered also apply to the panel method.

The panel method is common in opinion as well as in marketing research. With some modification it appears to be a very useful tool for on-farm research.

Characteristics

In the panel method **the same farmers participate** in discussions repeatedly on a research topic several times, idealy right from the beginning (the exploration of demand) up to the end of the development of an innovation (the final assessment). This gives farmers the chance to get familiar with the general concept of the research as well as with the specific topic, thus placing them in a position to effectively contribute to the research process.

Repeated contacts between researchers and farmers contributes towards building up necessary **mutual confidence**. The result is decreasing inhibitions on the part of farmers to express themselves and a more open and honest dialogue.

An appropriate expression of an opinion further requires that the **formation of an opinion** is fairly advanced on the one hand and that the interviewee is conscious of it, on the other . In particular with regard to the latter, the interviewee is often not aware of the reasons for his opinion if he is taken by surprise in a single interview. An opinion on a subject new to the interviewee requires time to develop. The formation process is usually not finished when, for example, a farmer is asked to assess a new technology

once after a trial season. Using the panel method, a more long-term dialogue on a subject helps the interviewee both to form an opinion and to become conscious of already developed ones.

One problem with the panel **technique may be the so-called panel death**: with time participants loose interest and need to be replaced, or panel groups may completely dissolve. An interesting and diverse selection of topics for panel discussions can avoid panel death to some extent.

It can be hardly avoided, however, that the **consciousness** of participants slowly changes with continuous participation in a panel. A change of participants after some years is, therefore, inevitable if representative views are to be gained from participants.

Application

With a careful selection of participants and a good selection of topics, the panel may be the **most appropriate tool for the dialogue on innovation.**

The same participants are used for discussions throughout the research process:

- in the **exploration of demand** to develop an inventory, to set priorities, or to validate researchers' hypotheses regarding demand;
- for **identifying options**, to draw up lists of criteria innovations need to satisfy in order to comply with farmers' criteria, or to select potential options from a set of available alternatives
- to **assess experimental treatments** in the course of experimentation.

Panel groups are applicable at all stages of the research process. Individual discussions are useful for the assessment of options with the participants of the experimental phase if a quantification of opinion is desired.

4.1.2.4 Observation and measurement

Observation and measurement is data collection based on visual examination or instrumental measurement.

Characteristics

Whereas the value of an interview depends to a large extent on the quality of the answer given, the value of observations and measurements only depends on their skillful and careful implementation.

Objective results are achieved through measuring, counting and weighing. Observing (for example the degree of pest infestation) is subject to the interpretation of the observer. Results can, therefore, be of a subjective nature. Strictly speaking, for results to be comparable, all observations on a specific matter should be conducted by the same person. Comparable results by different observers require sufficient practical training in order to achieve a good level of correspondence.

Application

Observations and measurements are the tool for the collection of **agronomic data in experiments**. Here they prove the relationship of the experimental treatments applied with yield and quality characteristics under given environmental conditions (see Chapter 5 "Experimentation" for further details).

Observations and measurements are furthermore an important tool to **supplement information obtained in interviews**. They are applied in informal (for the exploration of demand) as well as in formal surveys (for the assessment of technology). On the one hand, observing and measuring allows the researcher to grasp certain information faster and more precisely than is possible in an interview (for example, information on cropping patterns, spatial arrangements etc). On the other hand it can be used to validate verbal information obtained in an interview (for example to avoid incorrect results with regard to adoption or non-adoption of a potential innovation).

4.2 Application of data collection in on-farm research

4.2.1 Exploratory farming systems survey

The exploratory farming systems survey is useful as the **first step in the on-farm research process**. Basic data collection methods like secondary data collection, non-standardized interviews, group discussions and field observations are combined in order to get preliminary information about farming systems in a specific area.

Such a survey is often omitted because the procedures appear to be too difficult and time consuming and there is the understandable desire to achieve trial results as fast as possible. Where the exploratory survey is carried out, it is often the one-man-show of an economist and, hence, agronomically relatively superficial. Consequently it is rarely used as a basis for the planning of experiments.

The following chapter attempts to describe an approach to the exploratory farming systems survey which is simple enough for implementation in rural development projects and yet sufficient as a basis for the planning of trial programmes.

4.2.1.1 Objectives and purposes

The exploratory farming systems survey is implemented as the first step of the on-farm research process. It is undertaken in order to

- gain some understanding of the local farming systems;
- study the effects of natural and socio-economic circumstances on the development of farming systems;
- assess motives and decision criteria which influence farmers decisions;
- create an information basis for the identification of problems and potentials and for the definition of different "target groups" or "recommendation domains".

On the basis of this information the researcher will be able to formulate a **first hypothesis** on the existing demand for innovation.

A shortcut farming systems diagnosis can also serve as a means to get new research staff of a project fast and easily acquainted with the situation of farmers and is recommended after changes of key personnel even if the diagnosis was done already.

The exploratory farming systems survey as it will be described in the following section will permit only an incomplete assessment of farming systems and determining conditions. It will be the basis for the **researchers' perception** of farming systems, determining factors and systems constraints. The picture gained should not be assumed to be the truth. "What researchers believe the farmer thinks or needs is not necessarily what the farmer actually thinks or needs" (Ashby, 1990). The hypotheses on demand for innovation should therefore be validated in an intensive dialogue on innovation between farmers and researchers.

4.2.1.2 Characteristics

Different terms are used for this activity, including *informal, diagnostic or reconnaissance survey, rapid rural appraisal or diagnosis and design*. Despite differences concerning the methods applied, all have in common that

- the survey is conducted by an interdisciplinary team;
- the data collected are more of a qualitative nature;
- non-standardized, largely unstructured interviews are combined with observations;
- direct farmer – researcher interaction is conducive to the collection of information concerning farmers' goals, opinions values and knowledge;
- results are achieved rapidly and cost efficiently.

The exploratory survey is executed **before** the on-farm experimentation programme is designed. It helps to avoid a wrong direction of the experimentation programme.

Farming systems are determined by a variety of circumstances. The farming systems survey must therefore take an **interdisciplinary approach** in order to thoroughly understand all relevant factors. The danger of a single-sided approach is that important aspects are overlooked or omitted.

Consequences of **late, single sided or insufficient diagnostic work** at the beginning of a programme are often discovered only after years of programme implementation. Time and funds gained by initiating experimentation before a sufficient diagnosis was made may result in the utilization of scarce project resources for the development of technological components which eventually prove to be inappropriate.

The researcher has to be aware of **possible inaccuracies** in the information obtained caused by the informal character of the survey. Depending on sampling procedures the group of farmers interviewed may not be representative. Furthermore it will not be possible to generalize information obtained across all farmers interviewed, because the questioning is not standardized (FSSP, 1985).

The results of every step of the work should be sufficiently **documented**. Written documentation is helpful for the research team to get a common understanding of ideas and conclusions. Moreover it is an essential tool in explaining the logic of the subsequent programme design to observers and, more importantly, successors in the project. Often projects undergo drastic changes with a change of personnel because the logic of the predecessors is not clear to the successors.

4.2.1.3 Contents of the farming systems survey

The circumstances and goals of farmers determine present farming systems and production technologies as well as farmer's decisions concerning changes of technology. The farming systems diagnosis should therefore aim to understand of farming systems and practices in the light of farmer's circumstances and goals. It will not be sufficient to know the crops grown or the livestock kept and the agricultural practices applied. A reasonable understanding of natural and socio-economic circumstances as well as farmer's goals and priorities improves the chances that subsequently proposed changes of technology do not conflict with these factors.

The **"historical development"** of cropping or farming systems deserves special attention in the survey contents. Recent developments, resulting in todays situation, are an excellent indicator of the demand for innovation perceived by farmers and for farmers own strategies to satisfy this demand.

A rough outline of the essential points in a farming systems diagnosis is given in Table 4.1. Details with regard to significance, utilization and analysis of information gained during the diagnostic phase are given in Chapter 6.1, analysis of information from non-standardized data collection.

For the exploratory survey it is helpful to outline the interview contents in a **"topic guide"** after information gaps were identified in the analysis of background information. During the field implementation the topic guide is upgraded in daily roundup sessions (see survey procedures). A sample guide is presented in Annex 4.1.

Table 4.1: Suggested contents of the exploratory survey

1.	Farmers circumstances
1.1	Physical / infrastructural situations
1.2	Socio – economic institutional, economic, social and cultural, role of women
1.3	Natural conditions climate, land, soil and water
2.	Farming systems
2.1	Cropping pattern and land use
2.2	Production methods
2.3	Inputs and yields
2.4	Crop disorders
2.5	Post-harvest aspects
2.6	Livestock
2.7	Integration of crop and livestock production
2.8	"Historical development"of farming/croppg.systems and innovations already developed by farmers

4.2.1.4 Process and procedures

The exploratory farming systems survey consists ideally of the following methodological elements:

(1) secondary data collection and analysis;
(2) "field work" with:

- non-standardized interviews with key informants;
- non-standardized interviews with farmers;
- group discussions;
- field observations.

A possible procedure for the execution of the exploratory survey is given in Figure 4.1. Expected outputs of the elements are summarized in Table 4.2.

Figure 4.1: Suggested procedure for the exploratory survey

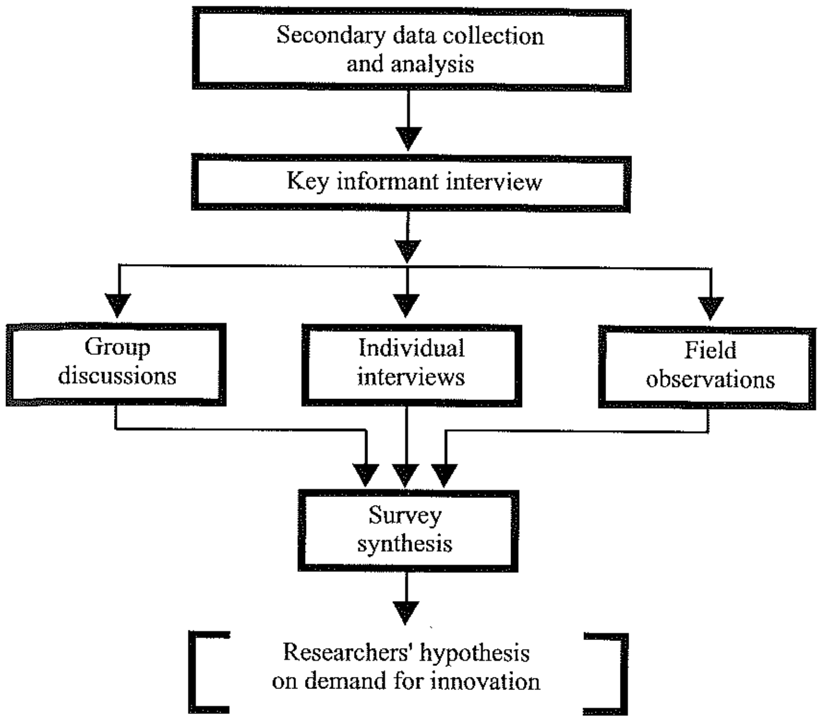


Table 4.2: Steps of the farming systems diagnosis and expected outputs

Steps of the diagnosis	Expected outputs
(1) Analysis of secondary information	– existing information summarized; – information gaps identified; – first hypothesis regarding target group definition and demand for innovations formulated ; – survey villages selected; – topic guide prepared.
(2) Field work	– farmers interviewed; – field observations executed; – topic guide updated daily ; – information on farming systems and practices, farmer circumstances and goals collected and recorded.
(3) Survey synthesis	– agro-ecological zones defined; – zones of similar socio-economic circumstances determined; – hypothesis on target groups / recommendation domains formulated; – inventory on demand for innovation elaborated and priorities set; – potential options to satisfy demand identified.
(5) Evaluation of diagnosis with farmers	– results of farming systems diagnosis evaluated with farmers.

4.2.1.5 Analysis of background information

The analysis of background information (also referred to as base data or secondary information) should help to

- summarize existing information on the physical and socio- economic conditions of the project area;

- identify gaps in existing information on the project area and thereby orient the exploratory survey;
- define preliminary target groups or recommendation domains;
- formulate hypotheses regarding the existing demand for innovations;
- and objectively select survey areas, appropriate villages and representative farmers.

The analysis will usually focus more on data **related to external (natural and socio-economic) circumstances**, whereas gathering information on farming systems falls more in the realm of field work.

Various **sources of information** may be tapped, such as maps, rainfall records, reports from government services, research stations, development projects, universities or NGO's. Written documents may be supplemented by verbal information. It should be kept in mind by the survey team, that the aim is not to collect, but to utilize information. It wise to carefully consider which information is worth analyzing at this stage of the research. A lot of information may be interesting but only some may be really useful. Information not required now can be filedand kept for later use.

The analysis of background information forms the basis for selecting representative survey areas or villages. The preliminary target group definition plays a key role in this respect. This may result in the exploratory survey concentrating on specific zones of the project area if available background data suggest a high heterogeneity of farmers' circumstances or farming systems and if the project area is to big too be covered all at once.

4.2.1.6 Field work

Field work is planned based on the the analysis of background data and considers in particular the information gaps identified.

In the following chapter some key issues with regard to survey methods and procedures, survey content and survey organization will be presented. Important aspects concerning communication and cooperation with farmers, which are also important in this respect, are dealt with in Chapter 6: "Some tips for communication with target groups".

Survey methods

Field work combines field observations and interviews.

Field observations are used to supplement and validate base data collected and information gathered in interviews. They may reveal discrepancies between social norms and actual situation. They are also useful in providing information concerning natural conditions, crops and cropping patterns, types of livestock and husbandry, marketing facilities etc. Soil samples for analysis may be taken, if there is no appropriate data base on physical and chemical soil properties available.

Field observations are combined with **individual interviews** in farmers' fields. This way, information on aspects such as cropping patterns and cultivation techniques (and their relationship to natural conditions) can be obtained and compared with information received from farmers immediately. Simple recording techniques are shown in. Also the time required for driving to the village or walking from field to field is productively spent if it is utilized for observations.

Interviews are the key element of the exploratory survey. Different types of interviews are used for different purposes:

Group interviews with the village community or parts of it are useful in getting a general description of farming systems, farmers' practices and system constraints perceived by farmers in the initial phase of the survey. They are also valuable at the end of the survey for discussing issues which are controversial or questions to which farmers responded differently in the individual interviews . "Discussion and dissent within a group can be especially fruitful in helping researchers to understand which criteria are held in common among farmers and which may reflect individual farmers different objectives or available resources" (Ashby, 1990). Group interviews are not appropriate for socially sensitive issues (like income or food availability) and may produce misleading impressions if they are dominated by individuals.

Interviews with individual farmers can provide in-depth information on farming systems, system components, agricultural practices and how these are determined by farmers goals and priorities as well as by external circumstances. If farmers are carefully selected, the interviews will allow some assessment of the diversity within the village community. In the absence of other farmers it is easier to discuss socially sensitive issues. If the interview is done in the field it can be combined with direct observations to validate the farmers' answers with regard to cropping patterns or practices applied. This is an important aspect because farmers have a strong tendency to present what they believe to be the view of the researcher.

Key informant interviews are done with individuals "who have a specialized knowledge of some aspects of local farmers' circumstances" (CIMMYT, 1980). They are particularly useful in gathering in-depth information concerning socio-economic circumstances. Depending on the information required, agricultural extension agents, government officials, staff members of NGO's, input suppliers, buyers of agricultural produce, shopkeepers or merchants, credit agents, etc. may be interviewed. Local leaders, especially knowledgeable and older farmers may be interviewed at the beginning of the survey to gain an overview of agriculture in the target area or to investigate changing farming systems and their causes. A considerable amount of information can be obtained with this kind of interview. Care should be taken, however, that official views are not regarded as proven fact.

Survey procedures

It is useful to reserve the first days of the survey for a **tour of the target area** and for group and key informant interviews to gain an impression of the natural conditions and an overview of agriculture in the area.

The research team's style of approach will determine the success of the survey. Some points that will help to create a relaxed atmosphere are summarized in Table 4.3.

In an informal survey the **interviews are unstructured, informal open conversations with emphasis on dialogue**. Questionnaires are not used. The use of an interview guideline to be prepared before the survey is, however, recommended to make sure that all relevant aspects are covered.

The **recording of information** during interviews is a controversial issue. It is often reported that farmers feel uneasy if notes are taken during the interview. The atmosphere is certainly more relaxed, if no records are taken. In this case the survey team will have to record the information gained soon after the interview. Some researchers think, however, they would miss important points if notes are not taken. The team should abstain from taking notes in any case until the situation seems to be relaxed. Before taking notes the farmer should be asked for his permission. The conversation will be least affected if only one team member takes notes, whereas the others concentrate on the dialogue.

The **duration of an individual interview** should, as a rule of thumb, not exceed 45 minutes unless the farmer is in a talkative mood. Group interviews may take a little longer. The interview should be terminated if there are signs that the farmer has lost interest or is becoming unwilling. The time will usually not be sufficient to cover the interview guideline completely. There are two ways of solving this dilemma: (a) the initial interviews cover broad aspects of the farming systems. Subsequently researchers focus on priority problems, potential solutions and interactions of these with other aspects of the farming system (FSSP, 1986). (b) the interview guideline is divided into different sections. Only one section of the guideline is discussed with every farmer (CIMMYT, 1985)

The informal survey is a **dynamic data collection** process. At the end of each day a **daily roundup team session** is held to evaluate the data collected, to complete notes where necessary, to check the initial hypotheses on production constraints and underutilized potentials and to reformulate the interview guideline in view of information gaps noticed. As the survey proceeds the focus becomes narrower and sharper.

Though the exploratory interview is considered to be **methodologically simple,** it is **physically tough** (CIMMYT, 1985). Depending on the distances to be travelled not more than 2-3 interviews per day and interview team should be aimed for. A survey duration of approximately 2 weeks appears to be the maximum. A short break for regeneration after half the time scheduled has proved useful.

Selecting of villages and farmers

The choice of **survey villages** is based on the analysis of background information. If the background information suggests a relatively **homogeneous** project or target area, an initial selection of 3-5 representative villages will be sufficient. Further villages may be chosen, if the survey reveals heterogeneity of natural or socio-economic circumstances. If distinct agro-ecological zones (or recommendation domains) were already identified in the analysis of background information, at least 2-3 villages per zone should be included in the survey. The villages should not be situated for convenience, on a tarmac road, as such villages are often atypical (Chambers, 1980). On the other hand they should not be too remote. Relatively easy access is advantageous, in particular if researchers are considering including survey villages in the trial programme later on.

Farmers can be either selected in advance or ad hoc in the field during the survey.

Table 4.3: Some points on how to create a relaxed atmosphere in the exploratory survey

- The research team should show consideration for local customs;
- in many societies it is appropriate to greet village leaders first before farmers are contacted;
- the initial contact with farmers should be utilized to introduce the survey team and to carefully explain survey objectives and procedures, how farmers were selected and which benefits farmers can expect or not expect;
- nothing should be promised which the team cannot deliver;
- the farmer is the expert on local farming systems and should be treated with due respect. The researcher is the layman who listens to and learns from the farmer;
- a location should be chosen for the interview where the farmer feels at ease. In case of the group interview this may be the tree in the center of the village where farmers usually meet or the compound of an individual farmer but not an extension center or a government office. Individual farmer interviews are most appropriately held in the field, where they can be combined with field observations;
- the right timing will influence farmers willingness to participate. Individual interviews in the field may be carried out in the morning, when the farmers are in the fields anyway. It is better to conduct a group discussions in the afternoon after farmers have returned from their field work to the village;
- in any case, it is important to ask farmers beforehand whether they have time for the interview;
- large interview teams will make farmers uneasy. Interview teams should therefore not be larger than 2-3 people;
- interviews are always conducted in the local language. If translators are required they should preferably not be from the survey village or otherwise known to the farmers, because this may bias the answers given.

A **selection in advance** has the advantage that farmers can be briefed about the survey and its objectives in head of time. An informed farmer is usually more accessible and less apprehensive than a farmer taken by surprise. Farmers can be selected using random sampling procedures, if complete lists of farmers (or farm families) are available for the survey villages. Where this is not the case, key informants can be asked for assistance or a village meeting can conducted in advance to select farmers.

For logistical reasons it may not always be possible to select farmers in advance. In this case an ad hoc selection can be done either at a village meeting on the first day of the survey, or farmers met working in the field are chosen randomly.

Care should be taken that a cross section of farmers is involved in the survey, such as:

- male and female farmers (both as members and heads of household);
- farmers with different interests (e.g. crops versus livestock, one crop versus another, etc);
- "traditional" and "innovative" farmers;
- subsistence and commercially oriented farmers;
- full-time farmers and farmers with off-farm employment;
- farmers working in different agro-ecological zones.

It is hardly possible to give a recommendation with regard to the appropriate **number of farmers to be surveyed per village**. Depending, among other points, on the heterogeneity of farms, the time available and the depth of information desired, a range of 3 – 10 is admissible. The higher the number of farmers interviewed, the more detailed the information obtained will be. As it will be impossible to completely understand complex farming systems and farmers' decision criteria, researchers should be satisfied with gaining a good impression and not spend too much time in one place. A village should be left when the survey team has the impression that only little additional information is acquired with every additional interview.

4.2.1.7 Survey synthesis

Eventually the information obtained will be synthesized and compared with researchers' hypotheses with regard to the demand for innovation, groups of farmers that have a particular demand and ways of satisfying these demand. The hypotheses are used as a basis for dialogue on innovation before an experimental programme is planned. The following analytical steps can be applied in order to achieve the synthesis of survey information:

- **the analysis of demand for innovation**, as it is determined by identified problems and potentials (→ **6.1.4**);
- **the definition of "target groups"** or "recommendation domains", i.e. groups of farmers which have a specific demand for innovation or which are likely to adopt a particular innovation (→ **6.1.3**);
- **the prioritizing of identified problems and potentials**, and
- **the identification of options to satisfy the demand (→ 6.1.5).**

The required analytical steps can be applied, for example, also on information obtained in a dialogue on innovation. They are, therefore, not described here, but in Chapter 6.1: "Analysis of information from non-standardized data collection".

4.2.1.8 Evaluating the diagnosis with farmers

The diagnosis described so far has included farmers mainly as resource persons. The identification of problems and potential solutions is, therefore, based more on researchers perception than on farmers' views. An active participation of farmers in particular in the identification and prioritizing of problems and potential solutions would be desirable in order to ensure that subsequent experimentation programmes are closely directed at farmers' needs.

Two possibilities for encouraging a desired participation are

(1) to do the "farming systems synthesis together with those farmers participating in the survey soon after the interviews are finished and to streamline the results achieved afterwards with the research team, or

(2) to do the "farming systems synthesis" with the research team. The identified problems and underexploited potentials are presented to farmers without showing the researchers' priority ratings. Farmers are first invited to add problems and potentials as well as potential options overlooked by the researchers. Thereafter they prioritize problems and potentials and screen possible options.

The choice of approach will largely depend on the **communicational skills** of the members of the research team. The first approach has the advantage that it is more open to farmers' own views. It is, however, highly demanding with regard to the communicational skills of the researchers. A danger of the second approach is that farmers may be influenced by the views of the researchers. Nevertheless, this approach appears to be advantageous, if the communicational skills of the research team are rather limited.

An appropriate forum for this activity are group or panel discussions in the villages included in the survey or likely to be included in subsequent experimentation programmes.

4.2.1.9 Organizational aspects

Farming systems and practices are determined by a complex of many different circumstances, as discussed in Chapter 2.
Farming systems diagnosis requires, therefore, an **interdisciplinary approach** in order to analyze farming systems and systems constraints in the light of the different determining factors.

The **core team** responsible for the whole farming systems diagnosis should be composed at least of an **agronomist** (viewing farming systems as determined by natural circumstances), an **economist or/and sociologist** (analyzing farming systems as determined by socio-economic circumstances) and an **extension** worker with knowledge of the target area. Sufficient professional experience of the core team is desirable. At least one member of the core team should also have survey experience and guide the other participants during the survey – "there is no substitute for experience – it is an art" (CIMMYT, 1990).

The **role of women** deserves particular attention. Women play a dominant role in agriculture in many developing countries. Interviews of women by male researchers will, however, be uneasy or socially not acceptable in many societies. It is, therefore, essential that the survey team also includes **female members**.

Depending on specific problems or underutilized opportunities expected in the target area, the survey team can be supplemented occasionally by **specialists** (like soil scientists, plant pathologists, breeders, livestock specialists etc) from research institutes or other relevant organizations.

The assistance of other organizations is in any case necessary if a project does not dispose of the required staff for the core team or if the project staff does not have sufficient field experience. The **participation of "outsiders"** can be valuable also for the identification constraints and opportunities which may be overlooked by "insiders" too familiar with the local situation.

As the exploratory survey will combine interviews and field observations, the most appropriate **time during the year** to do the diagnostic work will be during the **growing season**, preferably one or two months before the harvest when most crops are fully developed.

As a rough guideline, a **time schedule** for the diagnostic phase is proposed in Table 4.4. The time required for the collection of background information is difficult to estimate. It depends on the availability of information required, the sources to be tapped, the travelling involved etc. For field work, survey synthesis and farmer evaluation of the survey the time required depends, apart from factors like size and heterogeneity of the survey area, to a considerable extent on the intensity of the work. A realistic range will be between three weeks (for a relatively shallow survey as preparation for a more intensive "dialogue on innovation") and six weeks (for an intensive survey), if the survey is implemented as a full-time activity of the participants.

Table 4.4: Estimation of time requirements for the different activities of the initial diagnosis

Activity	Time requirement
Collection of background information	**?**
Analysis of background information and formulation of survey hypotheses	**3 – 5 days**
Field work	**5 – 10 days**
Survey synthesis	**2 – 3 days**
Evaluation of diagnosis with farmers	**2 – 5 days**
Writing survey report	**2 – 5 days**

4.2.2 Dialogue on innovation

The term "dialogue on innovation" covers all informal communication between researchers and farmers in the course of the on-farm research process. It is a flexible instrument for achieving the participation of farmers in planning and assessing programmes, or simply for obtaining farmers' views on a specific research subject.

The dialogue on innovation can take the form of panel or group discussions or of talks with individual farmers. It is most efficient when based on or done in front of practical examples or cases.

4.2.2.1 Application and output

The dialogue on innovation is applied in all stages of the research process which call for the participation of farmers:

- it is most commonly applied **to gain the farmers' assessment of innovations** in the course of experimentation. Farmers familiar with the alternatives tested in the experiment will discuss and compare their suitability. The information gained will help researchers asses to what extent a technology corresponds with farmers' goals and preferences.
- The dialogue on innovation is useful in the **identification of alternative options**
- (a) to develop a list of criteria or conditions for screening potential alternatives according to needs from the farmers' point of view the ex-ante screening of potential alternatives or
  (b) to identify potential innovations from a set of available alternatives.
- In the **exploration of demand** the dialogue on innovation can be used

  (a) to work out an inventory and to prioritize demand for innovations, or
  (b) to validate the hypotheses of researchers in respect to the demand for innovations (formulated possibly on the basis of the exploratory survey).
- It can **substitute the exploratory survey completely** where the availability of information about farming systems and determining circumstances is considered sufficient already.

4.2.2.2 Characteristics

The term "dialogue on innovation" is introduced to describe the role played by farmers in this stage of the process as distinguished from the role they play in survey research. Farmers are the active and equal partners of researchers in the dialogue on innovation, whereas they have the more passive role of informant in a survey.

The **basic element** of the dialogue on innovation is an open and unstructured **dialogue** between farmers and researchers. Though a list of topics prepared by the researchers will be useful, the dialogue should move in any direction determined by participating farmers.

The **subject** of the dialogue is the **assessment of or the demand for innovation.**

Discussion **on the basis of concrete cases or practical examples** is more promising than talk on theoretical or abstract topics.

The dialogue on innovation uses **non-standardized data collection methods** like the group discussion, the panel or the non-standardized interview with individuals. It is, therefore, of **an exploratory nature**. It is an excellent means to getting to know farmers' views, but it is not suitable proving their validity as it does not allow quantification.

The open character of the dialogue requires the participation of a person with a **comprehensive knowledge** of the subject to be discussed and **effective dialogue skills** on the side of the research team. This is usally the responsible researcher himself. Field-level personnel are often not qualified for this task.

4.2.2.3 Creating a basis for dialogue

A dialogue on the basis of concrete cases and practical examples will be more fruitful than theoretical discussions. Before the actual dialogue starts it is therefore necessary to **identify** or to **create** cases or examples.

In the following, some possible approaches for the dialogue on innovation will be discussed:

(a) **Group tours** through relevant villages are an effective basis for the **exploration of demand**. Villages should be chosen in which particular problems or potentials can be easily identified.

The group should be made up of farmers from the chosen village, a few researchers and extension workers and interested farmers from other villages. The latter is important because farmers from outside are in a better position to identify existing problems and potentials.

Walking through the fields provides the chance to talk about the role agriculture plays in the life of the village and about crops, cropping systems and production methods. Farmers can exchange views concerning the needs, problems and potentials which determine the demand for innovation.

The talks of the tour are summarizes in a round up meeting at a convenient place in the village (e.g. under a shade tree). An important topic for the discussion is the question how farmers from outside assess the relevance of the observed problems and potentials with regard to their own situation.

The analytical tools described in Chapter 6.1.1 to 6.1.4 can be used to structure the discussion and to summarize farmers views.

(b) **Visits to already existing experimental sites, research stations** or **fields of innovative farmers** are means of **identifiying options** to satisfy the demand for innovation.

The researchers identify appropriate sites in the vicinity of the project area where options to satisfy demand for innovation are being tested or applied already. Groups of farmers are invited to visit the sites jointly with the researchers. The discussions on the site of the experiments focus on:

- the criteria an innovation will have to satisfy in the view of farmers and
- the identification of options for on-farm testing according to the defined criteria. The analytical tools described in chapter 6.1.5 can be used for this purpose.

The most appropriate choice of farmers for this activity would be the potential participants in subsequent on-farm experimentation. This way they already get familiar with the potential innovations and researchers are more likely to enlist farmers who are really interested in experimenting.

If an experimental site or research station is not available, it is better to create a broad choice of examples for the dialogue on innovation in "exploratory trials" instead of going straight into intensive testing of a limited number of options. This decreases the likelihood that options which farmers may consider appropriate will have already been dropped in an early phase of the research.

(c) The best basis for the **assessment of potential innovations** is the **actual on-farm experiment**. **Dialogue with individual farmers** who participated in the experiment allows individual opinion to be quantified (see Chapter 6.2.2.3 for analytical tools). Quantification is, however, only useful if a representative choice of farmers participated in the experiment – which may not be the case in some phases of the experimentation (see Chapter 5.3.1). Furthermore an in-depth assessment with individual farmers requires considerable time and funds.

A better approach for exploratory purposes is the **dialogue with farmer groups** on **field days** and **field tours**. One discussion with a farmer group will usually yield more information than several talks with individual farmers. Group discussions also involve farmers who did not participate in the experimentation programme. They are, therefore, a good means of disseminating information and interesting new farmers in the next phase of experimentation. Field tours with farmers groups can assess a number of experiments in the same day. They are very time and cost efficient if several experiments are conducted simultaneously in the same village (see "representative village approach", Chapter 5.3.1).

4.2.2.4 Choosing appropriate farmers

For a village tour it is quite feasible to simply invite all interested farmers of the village to join in. Sometimes it is also possible to involve farmer groups which already exist for a different purpose. In general, however, a more fruitful dialogue is achieved with farmers specifically selected for this purpose. It is less important that farmers are chosen on the basis of being represantative than that they show:

- willingness with few inhibitions to communicate with researchers;
- ability to express their thoughts;
- experience with the topic to be discussed (every community has specialists for specific topics);
- keen interest in innovation.

In order to make a good choice of farmers according to these criteria, it is necessary to get to know farmers relatively well or to enlist the help of key informants who know farmers well. Village meetings or village tours are one way of becoming acquainted with farmers in the initial phase of the research. Village leaders or local extension workers can be key informants.

The "panel method" (s. 4.2.1.3) -in particular with panel groups- is very useful for the purpose of dialogue on innovation. The advantage of including farmers in the repeated dialogue throughout the research process is that:

- farmers become familiar with the general research concept and the particular topic;
- farmers get sufficient time to think about all relevant aspects of the topic and to develop individual opinions;

- there is a good chance of developing a relationship of mutual confidence between farmers and researchers.

(Refer to Chapter 6.1 for analytical methods that can be applied in the dialogue on innovation).

4.2.3 Formal survey

The formal survey is used for confirmatory purposes. It is applied to **verify** and **quantify** information or to **test hypotheses** formulated on the basis of information obtained through exploratory data collection methods (like the exploratory survey or the dialogue on innovation). Its basic element is the **standardized interview** which is applied on a **representative sample** of the target population.

4.2.3.1 Application and output

Formal survey techniques can be applied for many different purposes. In the context of this book they are useful at two stages of the research process:

- in particular in the final **assessment of an innovation,** to examine the degree of adoption and the nature of modifications applied by farmers who were exposed to the innovation in trials specifically designed for this purpose;
- to some extent also in the **exploration of demand**

  (a) to quantify information obtained in the exploratory survey (for example to set a baseline for adoption surveys to be executed in the course of the research);

  (b) to test a hypothesis which determines the direction of the subsequent research, if the validity of the hypothesis is uncertain.

4.2.3.2 Characteristics of the formal survey

In the formal survey a **uniform set of data** is collected from a relatively large number of farmers which, as a whole, are **representative** of the respective target group or area in order to achieve **quantification, reproducibility** and **comparability** of results.

The basic survey method is the **standardized interview** using a **fixed questionnaire,** which determines **the order and formulation of questions** to be asked. It may be combined with field observations in order to verify the answers obtained.

The use of a **fixed questionnaire limits the range of topics** that can be addressed and the **depth of the information** obtained. The formal survey cannot be as broad as the exploratory survey. The essential points should be decided before the questionnaire is designed. The formal survey can therfore be **effectively applied only if the necessary background information is already available** from other data sources (e.g. an exploratory survey or the dialogue on innovation).

An important advantage of the formal interview is that it does not need to be implemented by highly qualified staff. The application of the **standardized interview** procedure requires **enumerators** with a sound training on survey techniques, although they do not need a profound understanding of the research object and concept.

4.2.3.3 Survey process and procedures

Questionnaire design

The **contents** of the survey is guided by the purpose as well as by the information available already. In view of the limited range of topics that can be covered, sufficient background information is required in order to formulate the questionnaire efficiently.

The **length of the questionnaire** is determined by the concentration span of both interviewee and interviewer. Recommendations in the literature with regard to the maximum duration of an interview vary between 1 and 2 hours. The average duration should not exceed 1 hour - the shorter the interview, the better the response.

There are two different **types of questions** : the **open response** and the **closed response** question. The open response question leaves the answer entirely to the interviewee. The closed response question offers mulitiple choice answers. The advantage of the open response question is that it does not guide the interviewee. He is free to express his own opinion, whatever it may be. An serious disadvantage is that a wealth of different answers is difficult to categorize and code in the survey analysis. The prescribed answers to a closed response question facilitate an easy analysis. There is the danger, however, that the interviewee may respond negatively or inaccurately, because none of the suggested answers exactly describe his own opinion.

A compromise between the two types of questions is the **open response question with precoded answers**. In this case the interviewee is asked an open response question, but the questionnaire contains a number of likely answers, formulated on the basis of experience from the exploratory survey or the dialogue on innovation. The precoded answers should include "others" to take care of unexpected answers. The interviewer just chooses and marks the appropriate answer or specifies more fully if an answer falls under "others".

Table 4.5: Some tips on the formulation of questions

Use clear and simple language, avoid specialist terms, abstract expressions and abbreviations.
Avoid **normative expressions** or **suggestive questions** which will provoke a specific answer.
Avoid words and phrases which are **not exact** (like "general", "typical", "usual", "average", "often" etc). Vague questions will yield vague answers.
Keep questions short (not more than 15 words).
Solicit answers which do not comply with prevailing opinion or conventional rules (like extension recommendations) by indicating in the question that such practicies may be very common, well justified and not at all reprehensible.
Clearly define **location, time and context** on which the interviewee is supposed to base his answer.
Give **written explanations** where question may be difficult to understand. At the beginning of each section of the questionnaire there should always be a sentence or two to explain the new topic.
Write questions in the **local language** of the survey area. Where a translation of the questionnaire is necessary, it should be done by somebody who has an expert knowledge of the local language and is conversant with the concept and contents of the survey as well.

The **construction of the questionnaire** has a considerable influence on the **flow of the interview**. The following tips will help to achieve a pleasant flow of the interview:

- Questions belonging to the same topic are grouped in the same section of the questionnaire;
- questions should follow smoothly and logically from one to the next;
- possible logical sequences might be: a time sequence starting with the past, ending with the future; or moving from topics more familiar to the interviewee to less familiar ones, or from the more important to the less important ones;
- sensitive questions which may possibly influence the course of the interview should be asked at the end of the questionnaire or, if this is not possible, at the end of every section;
- each topic starts with general questions before going into specific ones. On the same line, open response questions are better asked before closed response ones;
- the whole questionnaire or some of the topics may not be relevant for all interviewees (for example questions on a specific crop). A "filter question" at the beginning of the questionnaire and of every new topic ("do you grow xy-crop, yes or no?") helps avoid answering a multitude of questions with "not applicable".

Bearing the subsequent **survey analysis** in mind at this stage helps to speed up data processing later. Categorizing unnecessary data often wastes a lot of time and effort. Where computer facilities are used, it should be possible to enter the information straight from the questionnaire – without data transformation. Where a **coding** of answers is not carried out correctly by the enumerators (which will often exceed their capability), facilities for ex post coding should be included in the questionnaire.

Pre-test

A **pre-test** of the questionnaire tests its applicability. It may result in the reformulation of individual questions or the revision of the entire questionnaire. The pre-test examines whether

- questions are easily understood by the interviewees;
- questions are correctly interpreted by the interviewees;
- the planned time limit is not exceeded;
- the questionnaire design facilitates a problem-free processing of the survey data.

The pre-test is preferably carried out by the enumerators after training with a specific selection of interviewees. Some 2-3 interviews per enumerator will usually suffice. The participation of the survey designers is desired, so that they are able to get an impression themselves of the existing problems with the questionnaire and of the performance of the enumerators.

Enumerator selection

In contrast to the exploratory survey, the formal survey does not need to be conducted by the researchers themselves. The standardization of order and formulation of questions allows "enumerators" to implement the survey. These can be either junior staff of the programme or people specifically selected for the purpose(for example, farmers' sons with sufficient education). An enumerator should have:

- a basic school education in order to ensure that the questionnaire is filled out correctly;
- an excellent knowledge of the local language for fluent communication with farmers;
- a reasonable knowledge of local conditions and agriculture to be able to judge the validity of the answers obtained;
- the respect for farmers required in order to create an appropriate interview atmosphere;
- the motivation to work hard an honestly.

Some of these points can be assessed already during the recruitment interview, others during training and questionnaire pre-test. It is preferable to eliminate enumerators during enumerator selection rather than during training, the pre-test or the survey.

The **number of enumerators** required depends on the planned duration of the survey as well as on the number of farmers to be interviewed. Considering the time for travelling, locating farmers, some courtesy talk and the actual interview considering also the fact that a good interview requires a fresh mind an interviewer will not be able to conduct more than two or (in rare cases) three interviews of one hour a day.

Enumerator training

Adequate enumerator training is a precondition for the success of a survey, in particular where enumerators are "laymen" in this field of work. Even with the most well-designed questionaire, a survey is bound to fail if the enumerators do not understand the survey objectives, have inappropriate attitudes or record data incorrectly. This applies to even a small survey, for example one examining adoption of trial innovations by farmers who participated in an experimentation programme. Training instructions should include:

- an explanation of survey objectives, concept and contents;
- an explanation of the questionnaire (all questions, explanations given in the questionnaire, the use of filter questions, etc);
- an explanation on how to record the answers;
- a description on how to contact interviewees;
- exercises on how to introduce the survey to the interviewee;
- basic rules of conduct during the interview;
- a description and tour of the survey area, if the enumerators are not familiar with it.

The training will be more effective if it includes not only theory, but practical interview exercises (either role-plays within the training group or with selected interviewees – possibly combined with the questionnaire pre-test).

The effectiveness of a large-scale survey can be greatly improved if an interviewer's manual is made available to the enumerators as a basis for training and as a reference guide for field work.

Sampling interviewees

The survey may not be relevant to all areas of the project or to all farmers within a specific area. The first considerations with regard to the choice of interviewees are therefore:

- which specific group of farmers is of interest to the survey;
- how is it possible to choose only members of the target population for the survey.

The answer to these questions is simple in the case of a survey which examines the adoption of trial innovations by farmers who previously participated in an experimentation programme. Here it is usually possible to include the total target population (i.e. all previous participants) in the survey.

Generally it is not possible to include the entire target population in a formal survey for the exploration of demand. In this case it will be necessary to interview part of the defined target population and to draw conclusions regarding the entire target population based on the sample. This requires the use of **proper sampling procedures**.

Using a random sampling procedure ensures that each subpopulation of the target population has an equal chance of being selected.

For **simple random sampling** every member of the target population is listed and a random selection of interviewees is made. The disadvantage of this simple method is the extreme difficulty in obtaining a complete list of farmers in a particular area.

Two-stage sampling therefore appears to be the more appropriate method. In this method a random sample is drawn from a list of administrative units or villages in the target area. In a second stage a random sample is selected from a list of farmers in each administrative unit or village sampled. In the absence of a farmer list, a rough map of houses in a village is drawn, the houses are numbered and the numbers randomly sampled.

The **sample size** should be large enough to be representative of all farmers in an area. Statistical rules for determining the sample size on the basis of the variability within the target population are hardly applicable for this type of survey. Proposed sample sizes for a defined target population vary between 30 and 50 farmers (CIMMYT, 1980; FAO, 1990). A larger sample size will be required, if a high heterogeneity of farmers is expected.

In order to find substitutes for farmers who were selected but could not be interviewed (because they were erroneously included in the selection list, were not relevant to the purpose of the survey, refused to participate or could not be found) a **reserve sample** (about 25 % of the original sample) is drawn up. The selection follows the same procedure as the original sampling (simple random or sampling by administrative unit/village).

Survey implementation

The **first contact** between interviewer and farmer strongly influences the success of an interview. Some hints on how to get in touch with farmers and how to gain their cooperation are given in Chapter 6.

The **timing of a survey** is also important in gaining the cooperation of farmers. A relatively slack period in the agricultural calendar is preferable. On the other hand, survey results will be better if the topics to be investigated are still fresh in farmers' memories. A **visit in advance** to agree on a day and time for the interview will ensure that farmers are available and have sufficient time on the agreed day.

Farmers not met at home should not just be replaced by a farmer from the reserve list. It may be that some of them belong to a specific group of people and are not at home for a good reason (for example off-farm work or employment). Wherever possible **return visits** should be tried on different days of the week or hours of the day.

The interview should be conducted in an **informal and relaxed atmosphere** at a place convenient to the farmer. An appropriate place for an interview concerning a specific crop would be the field where this crop is grown.

Relevant answers are obtained if the **primary decision maker** for the particular farm activity is interviewed, and not just the household head. Preferably only the interviewer and interviewee should be present. Answers are less influenced by considerations regarding **social desirability** in the absence of an audience.

Effective **supervision** is particularly necessary at the beginning of a survey. Such supervision is best carried out by the researcher who will be responsible for the data processing later on. A **daily editing** of questionnaires in the presence of the interviewer helps to improve enumerator skills in the course of the survey and minimizes data processing problems. The daily check should include aspects such as legibility and comprehensibility of answers as well as consistency and completeness of the questionnaire.

In the early phase of a survey it is also a good idea to **spot check** in the field whether the interviews are conducted according to the planned schedule. Some check questions can be (informally) incorporated into the talk with the farmers visited in order to verify whether the interviews are recorded correctly. As the survey proceeds, the level of supervision can be relaxed.

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Annex

Annex 4.1: Checklist for information about farming systems (adapted from Mutsaers et al. 1986)

1 Farmer circumstances

1.1 Physical/infrastructural circumstances
Maps, administrative divisions, physical infrastructure and accessibility, educational and health facilities...

1.2 Socio – economic circumstances
Institutional
Marketing and distribution mechanism,
intervention structures (extension and credit programmes..), farmer organizations ...
Economic
Population density and growth rate, settlement pattern,
off farm / non farm income opportunities and rel. importance,
land, labour and capital availability and sources,
crop statistics, marketed products, purchased inputs,
availability and demand for food, shortage periods availability of and demand for inputs/products price fluctuations, rel. prices for agric. products,
retail markets.
Social and cultural
Beliefs and attitudes, social obligations,
production goals, food preferences,
land tenure systems, ownership of and responsibility for crops/livestock, labour division by gender...
role of women.

1.3 Natural circumstances
Climate
Evapotranspiration, rainfall regime, median and quartiles of rainfall, critical periods, temperature, humidity.
Vegetation
Forest, bush or grassland, characteristic plant species.

Annex 4.1: Checklist for information about farming systems (adapted from Mutsaers et al. 1986)

Land, soil and water
Land form, land types and associated soils with frequency of occurrence, texture and colour of top soil, soil depth, hardpans, water table heights, water storage capacity, chemical fertility, occurence of soil erosion.

2 Farming Systems

2.1 Crops
Cropping patterns and land use
Crops, cropping patterns and crop associations,
utilization of different land types,
farm and field sizes,
products collected from the bush.
Cultural practices
Land preparation, planting, crop densities, weeding, manuring, soil fertility management, harvesting, cropping calendars.
Inputs and Yields
Crop varieties (desired and actual characteristics),
extend of inputs used (seeds, fertilizers, chemicals),
crop yields achieved.
Crop disorders
Pests, diseases, weeds and their control, nutrient deficiencies.
Post harvest aspects
Storage, processing, consumption, marketing,
food availability calendar.

Annex 4.1: Checklist for information about farming systems (adapted from Mutsaers et al. 1986)

2.2 Livestock

Types and breeds of farm animals,
ownership, quantities of livestock kept, herd composition, herd management,
husbandry practices, housing, equipment used,
feeding, types of feeds, seasonal availability,
watering / water availability,
diseases and disease control practices,
utilization and seasonal availability of animal products,
disposal or marketing of animal products, market demand,
utilization of draught power,
use, handling and storage of livestock manure.

2.3 Trees on the farm

Type, location and number,
use of tree products, economic value,
effects on crops, soil fertility effects,
fuelwood situation.

3 Synthesis

Agroecological zones,
zones with similar socioecon. conditions ,
definition of target groups,
farming systems, system trends and determining factors,
external factors affecting agric. production,
resources limiting agric. production,
management strategies applied to cope with limitations,
system constraints and underexploited opportunities.

Chapter 5 Experimentation

Annexes

Chapter 5 Experimentation

Experimentation is one, but not the only important component of the development of agricultural innovations. "The success of an innovation is eventually measured by its adoption" (see Chapter 2.3). In this sense experimentation will yield appropriate results only if sufficient time and efforts were spent beforehand on the exploration of the demand for innovation and on identifying suitable options to satisfy the discovered demand.

Experiments aim to provide the information required to assess potential innovations appropriately. Depending on the type of information required, experiments have a non-formal character (e.g. for information regarding correspondence with farmers' goals) or they follow a formal approach with suitable statistical designs (e.g. for most agronomic data). The weight accorded the formal approach in the following description does not mean that it is more important than the non-formal one. The formal approach requires a more detailed description to be applied appropriately.

5.1 Principles

Trial **objectives** and hence the **nature of information** to be collected determine the **course of action** and the **mode of implementation**. Table 5.1 shows some modes of implementation or "trial types".

The most vital information should be collected first

There is no logical sequence of data collection which is universally applicable to all experiments (see Chapter 2.4.3). The information considered most important to the success of a potential innovation should be collected first. This may sometimes be socio-economic information regarding wether a tested option corresponds with farmers' goals or it can be agronomic information.

Table 5.1: Some types of on-farm experiments

Criterion	Trial types
Purpose	– exploratory trial; – adaptation trial; – verification trial.
Farmer / researcher involvement	– researcher experimentation; – farmer / researcher joint experimentation; – farmer experimentation.
Type of innovation	– improvement of crops or cropping techniques; – introduction of new crops or techniques; – soil and water management practices; – etc.

Experimentation can serve different purposes

The information required about a potential innovation determines the purpose of experimentation:

Exploratory experiments

The **level of knowledge** concerning the effects and suitability of a potential innovation and the degree of confidence that it will work under the specific farm conditions of the area are lowest in the initial stage of the experimentation. Initially, therefore, the work is often of an **exploratory nature**:

- Exploratory experiments have an important function in the **exploration of demand** for innovation. It is often necessary, for example, to clearly **identify causes** for an identified production problem (like the cause of an observed plant disorder).
- Exploratory experiments can also be of help in the **identification of potential options**. Here they are applied as a basis for the dialogue on innovation. Researchers develop and offer a broad choice of **types of technology** which can potentially satisfy the identified demand for innovation. From these different types offered, farmers select a choice of

technologies which comply with their criteria. Finally the selected types of technology undergo in-depth on-farm testing.

- Exploratory experiments can lead into the actual testing stage. Experimentation often involves the **screening** of a large number of treatments (for example in variety or fertilizer trials). Both socio-economic information (which of the options available meets with farmers criteria?) and agronomic data (which of the options appear to be promising under the different environmental conditions given?) can be important at this stage.

Adaptation experiments

With **increasing knowledge** and confidence the investigation then focuses on the question of **adaptation** to **different environments** or to the **requirements of different target groups**. This may require agronomic data (for example to determine the stability of different options across different environmental conditions) or socio-economic information (for example to examine how different groups of farmers assess a tested option).

Verification experiments

In the final stage the trial innovation is used by a large number of representative farmers to **verify** that it functions under real production conditions. At this stage the information required will be more of a socio-economic nature. The focus will be on monitoring **spontaneous adoption** of tested innovations by the intended target groups and on observing what **modifications -** if any – are applied by participating farmers.

"Exploratory", "adaptation" and "verification" trials are sometimes considered **different stages of an experiment**. Not all of these stages are always necessary. Whether a specific type of trial really needs to be applied or not depends mainly on the information about the tested technology already available beforehand. In any case, however, it is recommended that the adoption of a potential innovation is tested thoroughly by a representative group of farmers before it is recommended on a large scale through extension.

Table 5.2: Different purposes of experimentation

Exploratory

- **Identify causes** of an observed problem (e.g. which disease or nutrient deficiency causes the observed plant disorder ?);
- **create examples** (pilot technologies) as basis for dialogue on innovation with farmers (to discuss demand for innovation or to choose from broad choice of options such technologies for further experimentation which match best with farmers preferences);
- **cut down** larger choice of potential options according to socio-economic(-dialogue on innovation) or agronomic criteria.

Adaptation

- **Test adaptation** of narrowed-down choice of options over the given range of environmental conditions;
- **adapt management** of potential innovations to resources and capabilities of target group;
- **explore compatibility** of tested options with goals and preferences of potential target groups through dialogue on innovation.

Verification

- **Investigate acceptability** of potential innovations across a **representative choice of farmers** .

The nature of information determines the intensity of farmer / researcher collaboration

An **intensive farmer/researcher collaboration** is required where **farmers and researchers jointly experiment**. Joint experimentation is desirable in most of the exploratory and adaptation experiments. The ideal, though hardly ever achieved, is farmer participation right from the planning stage up to the assessment of the experiment. This would ensure that:

- farmers views are incorporated in the planning of the experiment,
- farmers, conversant with the concept and objectives of the experiment, require only little support by researchers during implementation,
- farmers, familiar with concepts and objectives of the experiment and experienced in the application of the tested options, have a sound basis for their own independent assessment of the experiment.

This intensive farmer/researcher collaboration is, however, not required in all experiments. The exploratory trial to create examples (Tab. 4.2) is one example of a **"researcher trial"** which does not need farmer participation for planning or taking management decisions. Nevertheless, farmers assessment of the sample technologies will be the most important outcome of the experiment. Similarly, farmer participation may be restricted in trials investigating causes for observed problems.

Also testing the acceptability of a potential innovation in verification trials does not require intensive collaboration. It rather requires that participating **farmers themselves** are responsible for all decisions regarding trial implementation. Verification trials can be, therefore, easily run as **"farmer trials"**. Researchers' involvement is restricted to providing the new inputs or methods, explaining briefly their use and monitoring their application by farmers.

Apply appropriate comparisons

The validity of results depends largely on the **application of appropriate comparisons**. The most appropriate **control** is each farmers own technique and not an artificial "local average". Standardized **non-treatment practices** do not reflect real production conditions. Every farmer should rather follow his own practices. This also better enables the participating farmers to judge the benefits of a potential innovation. A standardization of control treatments and non-treatment practices is, if at all, only permissible

in the particular phase of a trial where the focus is on generating agronomic data to show the adaptation of various options to different natural environments.

Start small but as broad as possible

The number of trials should be restricted to the feasible. Often on-farm experimentation programmes are initially too big and ambitious. As a consequence, it is often the essential communication with farmers which suffers from time constraints.

Nevertheless it is advisable to consider as **broad** a choice of technology types as possible in the beginning. This increases the likelihood that such types of technology are chosen which are both agronomically appropriate and which satisfy farmers goals and preferences.

Starting small but broad means **implementing trials on a broad choice of technologies with a limited number of farmers** – but to involve many farmers in a dialogue on innovation in order to narrow down the choice of technologies for subsequent in-depth experimentation.

Seek an attractive range of topics

Not all research topics are attractive to farmers. Experiments which show immediate results (like trials on new varieties or crops) are usually more attractive than long-term experiments (like trials on soil fertility measures or tree crops). A good mix of "attractive" and "unattractive" topics keeps farmers motivated and helps the researcher to develop credibility with farmers.

Be timely

Timely execution of all activities is essential for the success of the programme. The involvement of farmers calls for an implementation of all activities considerably earlier than it is usual in a research station. Implementing on-farm experiments at the wrong time is a major cause of suboptimal results or complete failure.

It is almost usual in OFE programmes that the planning is done too late for a refinement involving trial farmers. Farmer selection must often be carried out with such haste that there is no time to choose the most appropriate. Common shortcomings are late provision of trial instructions, delayed distribution of required equipment or inputs or selection and layout are carried out too late for proper land preparation.

Figure 5.1: Changes of significance or extent of selected key criteria during the evolution of a proposed innovation

Criterion	Research phase		
	Initial		Final
	Research objectives		
	Exploration	Adaptation	Verifi-cation
Level of knowledge/ confidence with technology	+	++	+++
Farmer – researcher collaboration	+++	++	+
Required farmer expertise	+++	++	+
Data precision and detail	++	++	+
Possible significance of agronomic criteria	++	+++	+
Possible significance of socio-economic criteria	+++	++	++
Possible no. of treatments	+++	++	+
Management responsibility of farmers	+	++	+++
Number of farmers involved	+	++	+++
	+ = low		+++ = high

5.2 Designing on-farm experiments

The design of on-farm experiments is based on the exploration of demand for innovations (→ Chapter 2.4.1) and the identification the options potentially satisfying the demand (→ Chapter 2.4.2). The design transforms the potential options identified into on-farm experiments.

The design of the experiments involves a number of interlinked steps:

(a) defining trial objectives;
(b) determining the required environmental conditions;
(c) choice of treatments, treatment levels and arrangement of treatments;
(d) determining replications within and across farms;
(e) choice of an appropriate statistical designs;
(f) determining of the plot sizes;
(g) defining information to be gathered.

The following summarizes some essential considerations to be made for the planning of on-farm trials.

5.2.1 Definition of trial objectives

After defining the problems and proposing possible solutions in the diagnostic phase, objectives are set now which define what the research team and the farmers want to learn from the trial. The definition of objectives involves:

- the crop or crop association which is subject of the trial;
- the type of treatment to be tested and its effect;
- the nature of information to be collected for the assessment of the treatments;
- the natural and socio-economic environment under which the treatments are to be tested.

5.2.2 Defining desired natural and socio-economic conditions

This step is required if the trial covers **different agro-ecological zones** or other **differences concerning natural conditions** (such as soil differences within the same zone) or if **different "target groups"** were identified. Such differences should be considered because the potential innovations to be tested may

- not be appropriate for all zones and conditions or for all groups of farmers, or
- have different effects under different natural conditions, or
- be assessed differently by different groups of farmers.

Defining desired conditions helps, on the one hand, to **restrict the trial implementation to relevant agro-ecological conditions or target groups** and on the other hand to **allocate equal numbers of experimental units to all relevant zones or target groups**.

After relevant zones or target groups are identified there are **two alternatives for trial implementation**: (a) one trial is implemented for each zone or target group, or (b) one large experiment is carried out with "zones" or "target groups" as a component in a single hierarchical analysis of variance. The second option is preferable where it is desired to keep the number of farmers involved as small as possible. Both options facilitate the statistical **analysis of interaction between environmental factors and treatments** with regard to yield parameters. Furthermore both alternatives allow researchers to investigate whether different target groups assess the treatments differently, if target group characteristics were used as stratification criteria.

An **definition** of desired zones or farmer groups **before trial implementation** is clearly superior to a **stratification** after trial implementation, which bears a considerable risk that the one or the other relevant zone or target group is eventually underrepresented.

5.2.3 Choice of type and number of treatments

The **type of treatment**, defined by the trial objectives, effects a number of decisions with regard to trial design and implementation, namely arrangement and statistical design, plot size, necessary records and expected duration. Not the least it also determines the enthusiasm of participating farmers.

The **integration of new inputs** (like varieties, fertilizers or chemicals for plant protection) into existing farming systems is the most common and the simplest type of trial. It is relatively easy to test, it is normally attractive to farmers and it provides results relatively fast.

The introduction of new crops is a task which is more complex, but often crowned with success. It involves screening adapted varieties and developing appropriate production and storage techniques as well as examining marketing facilities, social acceptance etc. The introduction of new crops, sometimes tried for diversification of agricultural production, is in fact a relatively demanding interdisciplinary task.

A **change in cropping techniques or patterns** is promising only in connection with the introduction of new inputs or new crops or with drastic changes of production conditions. Experience has shown that without major changes in inputs or production conditions, cropping patterns and techniques are usually well adapted to the circumstances which farmers face. In particular, attempts to modify spatial arrangements or planting times often fail.

Testing **physical or biological soil conservation** practices addresses the growing medium rather than the crops grown. Results in terms of productivity increases can be measured only after several seasons. Farmers are, therefore, often not in favour of this type of trial, even where they suffer from serious soil fertility problems. It proved to be advantageous to combine this type of trial with research questions of a more short-term perspective in order to keep farmers motivated. Trials of long duration, large plots and frequent modifications of treatments during the trial must sometimes be approached in an unconventional way. Due to large plot sizes it is often not possible to accommodate the whole set of treatments in the same farmers' field. Small farmers are also often unable to maintain a uniform cropping pattern in all plots throughout the trial implementation. Intensive discussions with farmers to determine their preferences therefore may play a more prominent role in the trial analysis than data concerning changes in productivity, which can be better collected at experimental stations.

The **number of treatments** as well as the number of replications must be decided. In a trial with farmer participation as many as 8-10 treatments may be tested in exploratory experiments requiring only small plot sizes (e.g. the screening of different varieties). A **broad choice of alternatives** for farmer assessment in exploratory experiments reduces the risk that researchers leave out, on the basis of their own criteria, options which may be viewed favourably by farmers. Usually the number of treatments is considerably smaller in adaptation trials, depending on the technology involved and the plot size required. Not more than 2-3 treatments are applied in verification trials.

Suitability (is it really an answer to the identified demand?) and **relevance** (is it a realistic option for the farmer?) are examined for each proposed treatment. For example, full factorial fertilizer trials are useless if only a certain compound fertilizer is available to farmers. Or when testing intercropping systems, crop combinations or individual crops that will not be planted by the farmer should be avoided.

Farmers' practice is always the control treatment. Because of the high variability of "farmers' practices" the literature sometimes suggests the utilization of an average "local standard" (based on the most common local practice) as the control in order to increase the precision of the statistical analysis. It is not, however, the purpose of an on-farm trial to prove the superiority of a proposed innovation over an artificial standard but rather over the real, unfortunately highly variable, farmers' practice. It is therefore recommended that each individual farmers' practice be used as the control treatment. Where a standardized control appears to be necessary in exploratory or adaptation experiments (for example to analyze the interaction between environment and treatment) it is suggested that two control treatments (individual farmers and standardized) be used. In the verification trials only individual farmers' practice should be applied.

5.2.4 Arrangement of treatments

The most simple arrangement of treatments is the **farmer- designed** arrangement. In this case all participating **farmers individually decide** the arrangement of treatments. Farmers are only provided with test materials (like seeds) and/or some basic advice (not instructions!). Farmer-designed experiments are easy to implement. They are recommended for all experiments which mainly aim at gathering information on **farmers' assessment** of treatments.

Collecting agronomic data calls for formal and standardized arrangements. Some possible arrangements include

(a) a **single- factor** arrangement comparing different levels of one factor, or (b) a **complete factorial** arrangement comparing all possible combinations of the selected levels of two (or more) factors, or (c) an **"add on" or stepwise** arrangement for three or more factors in which supposed innovations are added factor by factor to the control (see Table 5.3 for examples).

A "**superimposed**" arrangement is one in which researchers add experimental treatments (like N-topdressing or pesticide application) to fields already planted by farmers.

The **number of treatment levels** is highest in the exploratory and lowest in the verification phase of a trial. The number of desired levels determines the choice of the appropriate arrangement. The highest number of treatment levels is possible in a single factor arrangement. A factorial arrangement with two factors will allow for 2 x 2, 2 x 3, 2 x 4, 2 x 5 or 3 x 3 factor levels (considering a maximum of 8-10 plots per farm). An "add on" arrangement only allows for two levels of each factor: the "farmers'" level and the "improved" one. The application of the "add on" arrangement therefore depends on the knowledge of appropriate factor levels.

In the **initial phases** of an on-farm trial, which often require the comparison of a relatively large number of treatment levels, **single factor or complete factorial** arrangements would be most appropriate. The **"add on"** version is suitable only for an **advanced phase** of a trial where it is particularly useful for providing information on farmers preferences for the different factors.

5.2.5 Replication within and across farms

Replication (i.e. implementing the same set of treatments repeatedly) helps to increase precision. With the increasing number of replications the chance to detect real treatment differences increases. In on-farm experimentation a distinction is made between **replication within farms** and **replication across farms.**

The more valuable type of replication is that across farms (i.e. implementing the same set of treatments at several farms within one experiment). This is required for the collection of agronomic data as well as for socio-economic information. It helps to achieve a good representation of different farmers' views and of the usually heterogeneous environmental and management conditions.

The necessity of replication **within farms** (i.e. applying the same set of treatments repeatedly within the same farm) is disputed. It can be useful for **agronomic data** if the interaction between farm conditions and treatments is to be analyzed. But it may not always be necessary for this purpose, because differences between farms can be related to:

- **environmental factors** (e.g. soils or weeds), and
- **management factors.**

A representative range of farms will take care of the factor "environment" within the farm / treatment interaction (see Chapter 5.2.2). Replication within farms is therefore only useful if there is a strong **management / treatment** interaction to be expected.

Table 5.3 Appropriate arrangements of treatments in on-farm experimentation

Arrangement	Features	Examples
Farmer designed	Completely open; very useful for assessment of treatments by farmers, often not appropriate for satisfactory agronomic data; applied in the exploratory and the verification trials.	
Single-factor	Compares the selected levels of one single experimental factor. Facilitates testing of rel. large number of factor levels. Used in all stages of OFE, for agronomic data as well as for farmers' assessment.	Varieties, fertilizer or manure levels or application technique, spatial arrangements, different green manuring plants, different phys.soil conservation measures.
Complete factorial	Compares all possible combinations of the selected levels of two or more factors. In OFE the number of factors should be restricted to 2. Facilitates the analysis of interactions between treatments. Applied in the exploratory phase, also for adaptation/refinement, useful for agronomic data collection, less suitable for farmer assessment.	Varieties x fertilizer levels, varieties x spatial arrangements varieties x time of planting, types x levels of fertilizer, physical x biological soil conservation measures.
Add on or stepwise	For testing more than one factor, each at 2 levels. Control is "all factors at low level"; the higher factor levels are added,one factor at a time, up to a desired "technology package". Facilitates testing of a number of factors simultaneously in a relatively small trial. Requires, however, some knowledge about factor effects and interactions: (-) factors are added in order of their expected importance (-) appropriate factor levels are to be applied (-) interaction effects cannot be analyzed. Applied in particular for verification/validation, also for adaptation/refinement, useful for farmer assessment, to some extent for agronomic data.	Step (1) everything at farmers practice; (2) as 1, but with improved variety; (3) as 2, but with fertilizer added; (4) as 3, but with increased plant population ("technology package"), or step (1) everything at farmers practice; (2) as 1, but with soil erosion structures; (3) as 2 but with green manure; (4) as 3, but with tree integration.

Replication within farms to gain precision with regard to agronomic data shoul therefore be kept to a minimum. The higher the number of replicates within a farm

- the less the farmer will be able to understand the trial and draw his own conclusions;
- the fewer the number of treatments and the smaller the plot sizes.

More than two replications per farm do not appear to be appropriate in trials with farmer participation. Testing a treatment twice per farm can be useful in exploratory or adaptation experiments to analyze farm / treatment interaction. For most trials (in particular where farmers assessment is the main objective) replication across farms with one replicate per farm will suffice. One replicate per farm should be the standard in verification trials.

5.2.6 Considerations for the statistical design of formal experiments

5.2.6.1 Relation between number of replications, treatments and zones

The number of **replications required** must be seen in connection with the number of treatments, the number of zones or target groups defined, the expected experimental variability and the magnitude of difference which the researcher needs to detect. As a rule of thumb, degrees of freedom for the error term in the analysis of variance between 15 (Mutsaers et al., 1986) and 20 – 30 (Hammerton and Lauckner, 1984) are suggested in the literature. 20 degrees of freedom appears to be reasonable if the variability due to environmental or management influences is expected to be relatively low; 30 appears to be more appropriate if it is expected to be relatively high. (Formulae for the calculation of degrees of freedom are given in Table 5.4)

Table 5.5 shows some examples of the **relation between the numbers of zones, replications within farms, replications across farms (=number of farms) and treatments**. It is apparent that the number of farms required to reach the desired degrees of freedom for error does not decrease significantly with increasing the number of replicates per farm from 1 to 2. As well the application of zones (or target groups) as an experimental variable does not change the **total** number of farms required considerably, though it reduces the number of farms per zone. Only the higher number of treatments in the early phase of a trial as compared to the final stage decreases the number of farmers statistically required.

Allowing for a relatively **high number of farms dropping out**, the **number of farms needs to be increased by roughly 10-20 % above the statistical minimum**. In practice, however, the number of replications across farms is often determined less by statistical requirements than by resource limitations (first by the staff required for installing, monitoring and supervising the trials and second by the means of transport needed).

Table 5.4: Calculating degrees of freedom for "error" (randomized complete block design)

Trial design		Degree of freedom for "error"
Replication within farm	**Different zones (or target groups)**	
no	no	df= (f-1)(t-1)
no	yes	df= z(f-1) (t-1)
yes	no	df= f(r-1)(t-1)
yes	yes	df= zf(r-1)(t-1)

df = degrees of freedom (error)
t = number of treatments
f = number of farms per zone (or target group)
r = number of replicates per farm
z = number of defined zones (or target groups)

Table 5.5: Design of on-farm experiments (randomized complete block)

Design criterion	Research Phase							
	Exploratory			Adaptation/ Refinement			Verification/ Validation	
Desired df (error)	20			20			20	
No. of plots/field	10			6			3	
No of zones,t.groups	1	1	2	1	1	2	1	2
No. of reps./farm	1	2	2	1	2	2	1	1
No. of treatments	10	5	5	6	3	3	3	3
Minimum no. of farms per zone/targ. group	4	5	3	5	10	5	11	5
Proposed no. of farms per zone/targ. group	5	6	4	12–15		6–8	30–50	15–25
Total no. of farms	5	6	8	12–15		12–16	30–50	30–50
Plot size	10–50 m^2			50–100 m^2			100–200 m^2	

5.2.6.2 Experimental designs

The research design most widely used and applicable in all phases of on-farm experimentation for almost all research objectives is the **"randomized complete block design" (RCBD)** with one or two blocks (=replicates) per farm. Its primary feature is the employment of blocks of more or less equal size, each of which contains all treatments which are **distributed randomly**. It is applicable for all treatment arrangements suggested in Chapter 5.2.3. In the randomization of factorial experiments all treatment combinations are treated alike.

In the **split plot design**, levels of the first (main) factor are placed in large plots ("main plots") which are sub-divided into smaller plots ("sub-plots") typically each containing all levels of a second factor. Split plot designs are appropriate in the exploratory or the adaptation/validation phase of a trial, if **cultivation practices required by one factor (like physical soil conservation measures or land preparation techniques) call for the use of large plots**. This factor will be assigned to the "main plot". It should be borne in mind, however, that measuring the effects of the main factor is less precise than for the second factor.

In **incomplete block designs** every farm contains only a fraction of the complete set of treatments. These designs are applicable where the size of plots and/or the number of treatments (possibly in trials dealing with soil conservation measures) does not permit the allocation of all treatments to one farm. It is recommended that these designs only be used in exceptional cases in the exploratory phase, because the comparison of treatments is rather difficult for the farmer and the analysis is relatively complicated.

5.2.7 Plot size

The plot size depends on the purpose of a trial, the type of treatment or innovation, the number of treatments and replications in relation to available field space and the homogeneity of the soil. Plot size also depends on the measurements and observations to be performed.

Generally plots are smallest in exploratory experiments and largest in verification trials. In exploratory experiments plot sizes are often determined by the necessary number of treatments and replications to be accommodated. In adaptation and verification trials the plot size is determined more by the measurements and observations required.

Trials should not impose burdens on the farmers. Hence it is important to consider whether the required labour will be available when it is needed without distorting normal farm operations and whether farmers will be able to bear the risks involved. As a rule, the total area required for a trial should **not exceed 5-10% of the cropping area of a farm** in the exploratory and adaptation stages. A slightly higher proportion may be permissible in the verification phase.

Conventional yield measurements require smaller plots than measurements of labour requirements, which need relatively large plots in order to provide fairly realistic results. Trials on varieties or fertilizer application will need smaller plots than trials on tillage, pest control or soil conservation measures. Plot sizes are increased if plant samples are to be taken before harvest.

An important aspect in on-farm experimentation is that **soil heterogeneity** is usually high under farm conditions. The variability of results decreases with increasing plot size. Agronomic data collection calls for plot sizes well beyond those applied at research stations in order to gain the required precision.

Larger plots

- increase precision of agronomic data,
- permit farmer management to be more realistically implemented,
- improve farmers' judgement of management and resource allocation problems,
- enable farmers to compare the productivity of treatments with their own means, and
- hence, give farmers a better idea of the advantages or disadvantages of a proposed technology.

Plot sizes should therefore be chosen as large as practicable

A distinction is made between **gross** (whole) and **net plots** (area of the plot in which observations and measurements are made and which is eventually harvested). Plants near the border of a plot can be affected by treatments or conditions of the neighbouring plot and may therefore not produce representative results. This can be the case, for example, in variety trials involving varieties with different growth characteristics (height, tiller or spreading characteristics), in fertilizer trials, in land preparation trials, in pest control trials, etc. These effects can be eliminated if border rows are defined during the experimental design. Measurements and observations are restricted to the net plot area excluding the border rows.

The significance of "**border effects**" and the number of border rows required depend on the type of the technology to be tested. 1 or 2 border rows at either side of a plot will suffice for most trials. Larger border areas are necessary, for example, in pest control trials where wind drift of spray dust or movement of pests from plot to plot may affect the results.

Table 5.6: Plot sizes for different experiments

Type of experiment	Plot sizes
Exploratory	depending on technology and purpose – often small (10-30 m^2 for screening of varieties) – can be large (like 100 m^2 as example for dialogue on innovation on soil fertility management during identification of options for experimentation)
Adaptation	commonly between 30 and 100 m^2 – 30–50 m^2 for variety or fertilizer trials – 50– >100m^2 for trials on cropping patterns, intercropping, soil fertility, pest control
Verification	recommended 100 m^2 or more (upper limit about 5-10% of farm area)

5.2.8 Data to be collected

The collection of data during trial implementation is not an end in itself. The data required are to a large extent determined already by the objectives formulated. Careful planning of measurements, observations and opinions to be recorded helps to make sure that the data needed for an appropriate analysis are made available and to avoid wasting resources gathering unnecessary data.

Data to be gathered can be differentiated according to

(a) their nature

- primary experimental data (data on those variables defined under objectives which are supposed to show the response of the experimental material to the treatments applied),
- information on the environmental setting, (natural and socio-economic environment),
- supporting data (on field operations performed, resources used, pests and diseases and other factors affecting trial results);

(b) their importance

- essential data, the "key set" of data required to do a meaningful trial analysis,
- useful data, helping to interpret trial results,
- unnecessary data, which are often recorded in large quantities as a routine but never utilized.

The data required are different from trial to trial. They depend on the type of the technology to be tested and on the questions to be answered by the trial. A key set of data considered essential in all cases is presented in Table 5.7.

Table 5.7 Key set of trial data

Primary experimental data (depending on defined objectives)

- yield parameters as defined by objectives,
- farmers' response
  (a) end of season = farmers assessment of
    - produce quality (colour, processability, cooking quality, taste, storability);
    - effectiveness of resource utilization (productivity related to area of land, inputs and labour);
    - availability of inputs and marketability of produce;

  (b) in season following trial season
    - adoption/degree of adoption of tested technology;
    - reasons for adoption/non adoption;
    - modifications tried by farmers.

Supporting data (useful for analysis of agronomic data)

- germination count or score;
- harvest standcount;
- count of missing hills or measurement of vacant area;
- dates for key field operations;
- inputs used (type and amount);
- dates describing crop development (emergence, flowering,maturity);
- factors affecting crop development (weed infestation, pests and diseases,mistakes made, effects of soil variation).

Environmental setting

(a) socio-economic conditions
- describing representateness of farm, like: farm size, family size, labour sources availability of/distance to input and produce markets;
- necessary for economic considerations, like: input costs and produce prices at local markets;

(b) natural conditions
- rainfall (daily records);
- slope, location in toposequence;
- soil (depth limitations, stoniness, texture, org. matter, if possible laboratory analysis for macronutrients ;
- plot history (duration of cultivation;crops and fertilization last season).

5.3 Implementing on-farm experiments

5.3.1 Organizational aspects

Good organization is vital to the efficient execution of the trial programme. The issues discussed below include farmer organization, staff organization, training and equipment required for the planned implementation.

5.3.1.1 Farmer organization

The mode of farmer organization determines

- representativity of results,
- travelling / transport requirements of the programme,
- the number of farmers who can be efficiently monitored,
- the quality of communication with farmers, and eventually
- the confidence of farmers in the research staff.

Travelling to visit farmers during trial implementation is not only the most costly factor but also the most time consuming activity in the execution of on-farm experiments. An efficient organization of participating farmers helps to reduce transport costs and travelling time required per farmer. Consequently more farmers can be looked after and/or more time is available for communication with every individual farmer. Better communication will eventually improve mutual trust between farmers and researchers.

Of all the possible **modes of farmer organization** two ends of the spectrum are presented here:

(a) a scattered distribution of farmers and
(b) a "representative village approach".

With a **scattered distribution**, farmers are relatively uniformly distributed within a given target area. The approach is quite common, in particular in extension programmes with a favourable distribution of field staff. The approach facilitates the choice of representative farmers or farmers working under representative conditions, provided appropriate selection criteria are applied. The major disadvantage of the scattered distribution of farmers is that the time required per farmer is relatively high just for travelling. The practicality of this approach clearly depends on the size of the project area and the quality of the road network. A result frequently observed is that communication with farmers is restricted to a minimum and an effective "dialogue on innovation" for farmers' assessment of the trial technologies is not achieved unless the number of farmers is kept low. More often than not sketchy supervision also results in poor agronomic data.

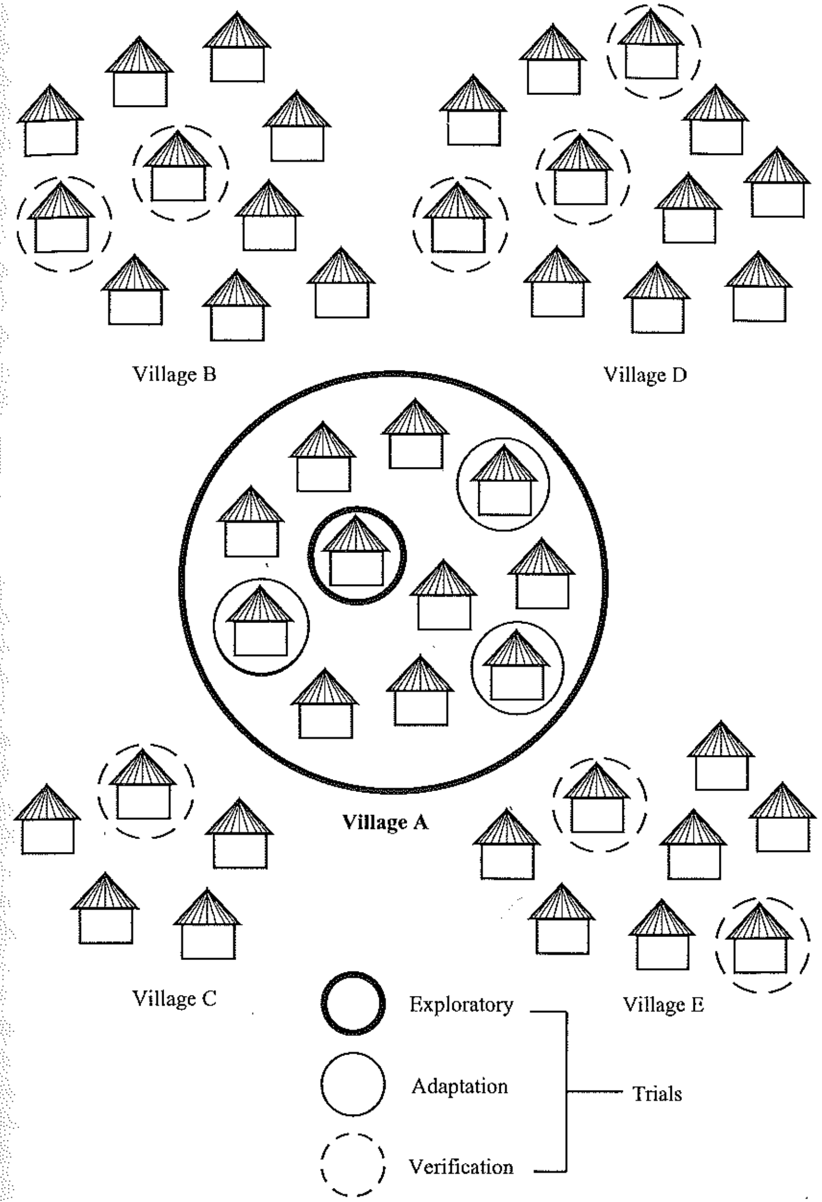
In a **representative village approach** a small number of villages are chosen which represent the natural as well as the socio-economic conditions of the programme area. A practicable procedure is to define zones with relatively homogeneous natural and socio-economic conditions (see Chapter 2.4.3) and to identify one or two representative villages within every relevant zone for trial implementation.

Within every village the required number of suitable farmers is selected. The chosen villages are particularly involved in the **exploratory and adaptation** phases of a trial, which require intensive communication with farmers and/or detailed and exact observations and measurements.

During the **verification** phase the trials are carried out on a larger scale with representative farmers in the **area surrounding the trial villages**. In this phase farmers are guided by extension workers whereas the involvement of researchers is restricted to a minimum.

The representative village approach eases communication with farmers as well as data collection and supervision of field work. It facilitates the use of field days and community meetings as means of communication. The employment of specially assigned field staff is simplified. The approach requires, however, a clear and detailed description of agroecological zones. Furthermore it may hardly be feasible without specific field staff for advising farmers and for data recording, because the concentration on few villages in the early stages of a trial can result in a relatively high number of farmers per village.

Figure 5.2: Distribution of farmers in a representative village approach



How long should the same farmer be involved ?

Regardless of the approach chosen, it is worthwhile considering **how long the same farmer should be involved in trial implementation.** Experience has shown that a long term involvement of farmers is advantageous in those phases of a trial which require intensive communication between researchers and farmers or precise trial implementation, i.e. in the exploratory and adaptation stages. An important factor in this respect is that it requires sufficient time to achieve the necessary relationship of mutual trust between farmers and researchers. A further advantage is that farmers' understanding of the principles of trial implementation improves from season to season.

It is therefore a good idea to maintain the cooperation with the same farmers over a number of seasons for trials in the exploratory and the adaptation stages. A change of farmers will be, in any case, required when an experiment enters the verification stage. Then participants representative of the intended target group are needed to study the acceptability of the trial technology rather than farmers who are already familiar with the principles of the experimentation.

5.3.1.2 Staff organization

On-farm experimentation is relatively undemanding with regard to the personnel required. Programme contents and methods, however, need to be adjusted to the personnel actually available. Project practice has shown that sophisticated programmes require highly skilled personnel whereas simple programmes can be run with just a minimum of staff.

There are ussually two **levels of personnel**: the **professional** research staff and the **field staff**.

The ideal staff composition at the **professional level** consists of an agronomist and an expert with a socio-economic background. The first is responsible for the agronomic aspects of trial design, data gathering and analysis whereas the latter takes care of social and economic aspects – in particular farmers assessment of tested technologies. The exploration of demand for innovation and the identification of appropriate options for experimentation should be implemented as a team activity.

In most programmes only one of these two experts will be available. In smaller programmes it may be sufficient to work with **part time staff** at the professional level. This can be achieved either by employing appropriate short-term experts or by involving extension staff with sufficient know-how concerning on-farm experimentation in part-time research activities.

Care must be taken that programme contents and methods are adapted to the professional skills of staff at this level. Without professional staff with a reasonably high level of knowledge concerning agronomic research methods, the focus of a programme should be more on the verification of results obtained elsewhere rather than on the development of new solutions. Data gathered in this case would be of a more qualitative nature, concerning, for example, the response of farmers, the adoption of tested solutions and modifications undertaken by farmers, rather than exact agronomic data. There is some risk that agronomic data collected without sufficient know-how could be inappropriately used; i.e. that they claim a precision which does not exist and that they are subject to misinterpretation if principles of trial design and analysis are not appropriately applied.

Table 5.8: Number of farmers that can be assigned to one staff member

Extension field staff (part-time implementing trials)	2-4	farmers
Research field staff (full-time implementing trials)	15-25	farmers
Professional level research staff	50-80	farmers

Experience has shown that the management and supervision of an OFE programme of reasonable size is a full time job. With only part-time staff at the professional level, an **intermediate staff level** between the professional and the field staff which may be called “supervisors” is required. The responsibility of the supervisors will be mainly the logistical planning, guiding of field staff during the season and verification of data recorded by field staff.

The **field staff** assists farmers with the trial implementation and do a considerable part of the data recording, in particular concerning agronomic and other measurable or easily quantifiable data.

A question often considered with regard to field staff is, whether **specially assigned staff** should be employed for trial implementation or already **available extension staff** should be used. An experience with the latter approach is that it is difficult to motivate extension staff to take over the trial implementation as an additional task. The fact that it is usually the better members of staff who are chosen to perform additional duties is to be borne in mind here. As a result, many of the trials established eventually fail. Rates of failure as high as 50% to 80% were observed in some programmes conducting trials with extension field staff. The implementation of experiments by **extension field staff** appeared to work satisfactorily only in projects which considered on-farm trials as part and parcel of the extension work.

Considering costs and impact of trial failures, it seems to be advantageous to employ special staff to at least carry out those trial phases which require accurate field work and precise agronomic data. This can be achieved, for example, by relieving extension workers from other duties as long as the trials are carried out.

A suitable **compromise** would be to employ **specially assigned staff** for exploratory and adaptation experiments, especially if farmers are selected according to a representative village approach. The verification phase, which requires less precise data of a more qualitative nature and only little guidance to farmers, can be implemented by extension staff within the framework of normal extension activities.

Table 5.9: Responsibilities of different staff levels in the implementation of on-farm experiments

Professional staff
- designing experiments;
- annual work planning;
- revision of trial design and work planning with trial farmers ("dialogue on innovation");
- training of farmers and field staff;
- analyzing trial results;
- gathering data regarding farmers response ("dialogue on innovation").

Professional staff or supervisors
- planning and provision of equipment and inputs;
- checking field selection, layout and execution of field operations;
- guiding field staff during trial implementation;
- verifying data gathered by field staff.

Field staff
- selecting trial fields;
- laying out trial fields jointly with farmers;
- guiding and assisting farmers during trial implementation;
- gathering agronomic data and data on environmental background conditions.

5.3.1.3 Equipment required

On-farm experimentation is impossible without transport facilities for all staff levels. This represents the most important equipment cost. In addition only very basic equipment is necessary for input and yield measurements, for field layout, rainfall measurement and soil sampling. A list of essential equipment is given in Table 5.10.

Table 5.10: Essential equipment for on-farm experimentation

- motorcycles or bicycles for field staff (depending on distances to be travelled);
- motorcycle or 4-wheel-drive vehicle for professional staff;
- tape measures (field staff, 1 per person) ;
- spring balance scales (field staff, 1 per person) ;
- field notebooks (field staff, 1 per person) ;
- rain gauges (field staff, 1 per person) ;
- gunny sacks or bags (to collect harvest produce);
- small paper, cotton or plastic bags (for input distribution and crop sampling);
- soil auger (if soil samples are to be taken);
- precision balance (if precise measurement of inputs, e.g. seeds, fertilizer or chemicals, should be required).

5.3.2 Programme activities

Timing of activities

The timing of programme activities depends largely on the type of treatments to be applied. In the case of "superimposed" treatments applied in fields already planted by the farmer (e.g. pest control techniques) it may be early enough to start activities at the onset of the season. An early initiation of programme activities is, however, necessary if a trial requires specific land preparation or planting. A time schedule for the latter kind of trial is proposed in Figure 5.3.

Revision and refinement of trial design with farmers

An important activity is the **revision and refinement of trial designs and workplans with those farmers potentially involved in the implementation** of the trial programme. Group discussions are the most appropriate means for this step. In a representative village approach (see 5.3.1) these discussions are done in village meetings in those villages chosen for the implementation of the exploratory and adaptation phases of the trials.

Choosing farmers

The meetings can be eventually utilized also to **choose farmers for participation** in the exploratory or adaptation phase of a trial. After the revision of the trial designs with the group of farmers is finalized, objectives and contents of every trial discussed is summarized by the research staff. Thereafter farmers are asked to volunteer for participation. The final choice is made by the researchers according to a set of criteria defined beforehand (see example in Table 5.11).

Figure 5.3: Time schedule for staff involved in on-farm experimentation

Activity	Months before trial season 5	4	3	2	1	Trial season <——>	Between seasons <——>	Season after trial season	Responsible staff
Preliminary trial design	■								Profess. staff
Farmer meetings (trial revision, farmer selection) (= dialogue on innovation)		■							All staff
Final design of trials, instructions,record forms			■						Pofess.staff
Training of field staff, training of farmers			■						Profess. staff or supervisors
Distribution of inputs									Supervisors
Field selection				■					Field staff
Field layout/demarcation				■					Field staff/farmers
Planting						■			Farmers/Fstaff
Monitoring						■			All staff
Fielddays (= dialogue on innovation) fieldtours						■			Profess.staff
Trial harvest						■			Farmers/Fstaff
Study farmers' feedback (= dialogue on innovation)							■		Profess.staff
Assessment of adoption/ modification by farmers								■	Profess.staff or supervisors
Agronomic trial analysis							■		Profess.staff
Socioeconomic analysis								■	and supervisors
Feedback to staff&farmers								■	Profess.staff

A number of further procedures for the selection of participating farmers is drawn up in Figure 5.4. With regard to the exploratory or adaptation phases of a trial, a preselection of farmers according to defined criteria can be made by field staff, by key informants or by farmers previously participating in trial programmes. The preselected farmers are invited to group discussions which are used to refine trial designs and to do a final selection of farmers for participation.

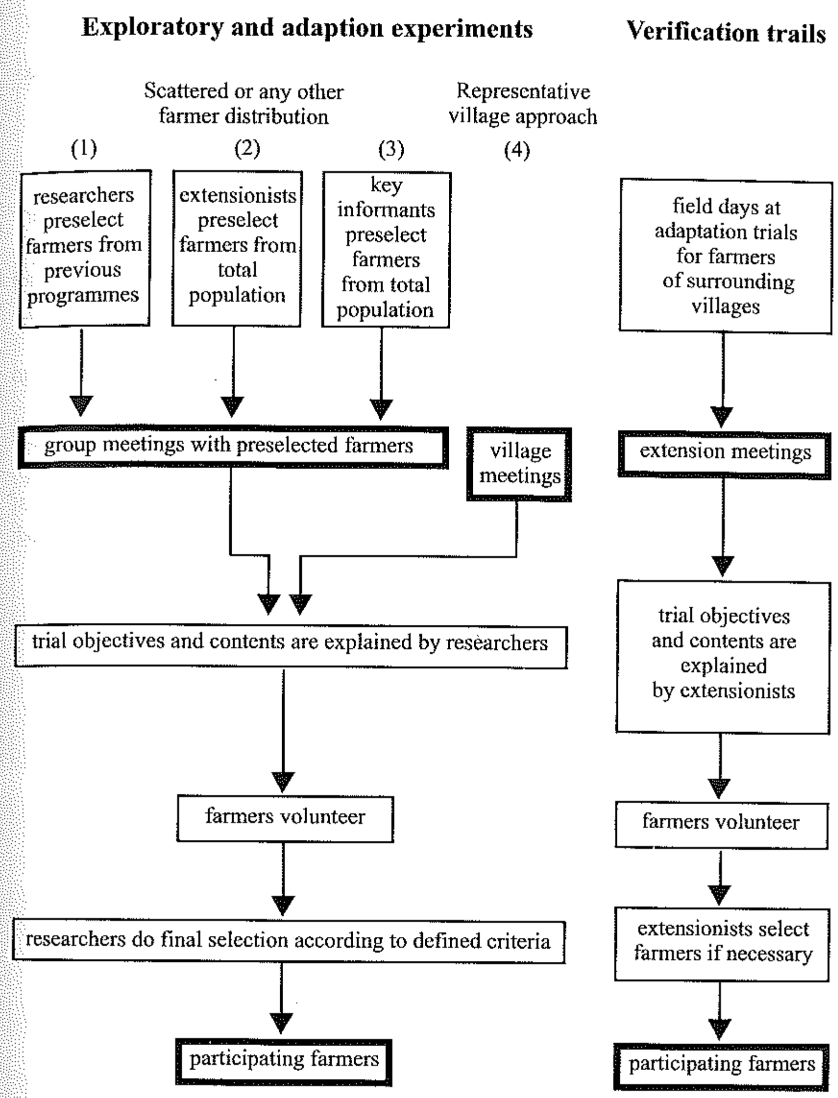
A broader participation of farmers is aimed for in the **verification phase** of a trial. One practicable approach for farmers' selection is shown in Figure 5.4. During the adaptation phase of a trial, farmers of the surrounding villages are invited for field days to discuss objectives, contents and results of the trial. In the following season farmers of the respective villages are invited to participate in the subsequent verification phase. A further selection from volunteering farmers may no longer be necessary at this stage. It is better to work with more participants than necessary rather than to offend an interested farmer. A high number of volunteers also indicates that the trial technology meets farmers' demand.

It appears to be feasible and appropriate to integrate the verification phase into extension programmes. The level of support to farmers is relatively low as this phase requires almost no activities apart from explaining trial objectives, contents and procedures as well as recording of required data.

Provision of inputs

A controversial issue is that of providing inputs to trial farmers free of charge. An important argument against this is that it may bias farmers in favour of the trial technologies or cause them to withhold their true opinion on a potential innovation if a repeated provision of inputs is expected. Some incentives, however, may be required to motivate farmers to participate in the programme. This is especially the case at the beginning of the programme or when technologies are tested of which farmers are somewhat skeptical. A reasonable compromise would be that farmers provide those inputs (like local seeds) which they use anyway, whereas the programme provides the new inputs to be tested (e.g. seeds of new varieties, fertilizers). If this arrangement is used throughout all phases of a trial, it is of particular interest to monitor to what degree farmers adopt the new technology in the first season after participation in the trial. Fixed rules on the provision of inputs are not proposed here as the appropriate procedure largely depends on the local situation.

Figure 5.4: Different possibilities for farmer selection



Training of farmers and field staff

Annual training of farmers and field staff is useful to

- clarify roles and expectations of farmers, field staff and researchers;
- familiarize farmers and field staff with the principles of on-farm experimentation and
- introduce farmers and staff into the implmentation of the actual trial.

The training of field staff and of farmers participating in the exploratory or the adaptation phase of a trial should be generally **carried out by professional staff**. The basic training necessary for the verification phase can be implemented by the responsible field staff member equipped with appropriate guidelines.

Timely training helps staff and farmers to select suitable fields and to plan field layout and all subsequent operations correctly.

The **subject of training** (see Table 5.12) is basically the same for field staff and farmers, though differences with regard to detail and depth are appropriate. As the experience of farmers and staff increases in the course of long-term cooperation, contents and depth of training must be adapted. Joint training of farmers and staff is not always socially acceptable.

Table 5.11: Some criteria for the selection of villages, farmers and fields

(1) Villages
- Representateness (based on results of diagnostic phase), e. g.:
  - regarding natural conditions (topography, soils, rain etc.);
  - regarding socio-economic circumstances (access to markets, off-farm employment opportunities, ethnic composition, etc.);
- accessibility during rainy season;
- distance to researchers' duty station.

(2) Farmers
- Genuine interest in participation;
- ability to provide appropriate land and required labour;
- representateness (based on results of diagnostic phase), e. g.:
  - regarding resources (land, labour, inputs commonly used);
  - regarding production goals (subsistence or commercial orientation, crops or livestock);
  - regarding income from / time spent for non or off farm work;
  - regarding age, sex, ethnic group or other relevant criteria;
- cultivation of test crop as a routine (if applicable);
- high level of experience with test crop (if applicable);
- good ability to communicate with researchers/express thoughts;
- known by community as local experimenter.

(3) Fields
- Representateness
  - regarding natural conditions of the area;
  - regarding defined trial objectives;
- accessibility during rainy season;
- remoteness (consider efficient utilization of time);
- uniformity of soil within trial plot;
- crop history (consider whether uniform cropping pattern, fertilization, husbandry practices were applied within field; avoid virgin land as well as fallow plots);
- farmers' intentions with field for trial season (select only fields which were to be planted with test crop anyway).

Table 5.12: Important subjects for farmer and staff training

- Definition of "experimentation".
- Explanation of the role
  - the farmer will play;
  - field staff will play.
- Reasons why farmer's role is important.
- Explanation of what farmers can hope to gain.
- Explanation of what farmers cannot expect.
- Description of objectives and purpose of the present trial.
- Information researchers are interested in.
- Detailed description of treatments.
- Explanation of
  - field layout and demarcation;
  - treatment application;
  - execution of field operations
    - following farmers' own practices;
    - uniformly applied to all plots of a field.
- Explanation of data recording (including significance of respective data for trial analysis).
- Contributions expected from the farmer (e. g. seed, land, labour, ideas and opinions etc.).
- Contributions to be expected from the researchers (e. g. support during trial season, ideas and opinions, inputs).
- Explanation of what is going to happen with harvest.

Plot layout and demarcation

Plot corners are demarcated with pegs and plots are labelled in order to facilitate an easy identification of treatments in the field. Trial layouts and demarcations are made by field staff in cooperation with participating farmers.

For those trials which require a special land preparation, it is advisable to lay out the trials and demarcate the plots before farmers cultivate their land in order to give them sufficient time for preparation.

In many cases it will be necessary to adapt the layout plan given in the trial instructions to the conditions actually existing in the field. The necessary basis for this can be created by practical exercises during the staff training.

Trials frequently fail because field staff and farmers do not sufficiently understand symbols or abbreviations used to identify treatments in the layout plan or on plot labels. A test of symbols or abbreviations used before trials begin can help avoid mistakes. Care should be taken that the same symbols or abbreviations are consistently used in the layout plan, on the plot labels, on containers in which inputs are provided and on bags distributed for trial harvest.

Application of treatments and execution of other field operations

An important principle regarding field operations was already mentioned under "Planning of on-farm experiments" (Chapter 5.2): as a rule, every farmer follows his own practices with regard to non-treatment operations. An exception (i.e. the standardization of non-treatment operations) is permissible only if the trial objective is to clearly prove the adaptation of treatments to different natural conditions (e.g. soil or rainfall) and if it is likely that management differences will change the results.

Nevertheless some kind of "standardization" is necessary. Altough they are self evident, the following points will be mentioned here because they deviate considerably from the usual farm practices and their omission often causes trials to fail:

Within a given trial field all field operations should be
- applied uniformly in like manner to all plots;
- finished within the shortest possible time, preferably not exceeding one or two days.

In **exploratory and adaptation experiments** it may be necessary that **treatments** are applied jointly by farmers and field staff in order to achieve useful results. In **verification trials**, the application of treatments is demonstrated to and discussed with farmers during farmers' training. A brief repetition with every farmer in his trial field just before planting is usually advantageous. Treatment application is left to the farmers. The way treatments are applied already reveals attitudes of the participating farmers. Observation of how farmers handle treatment application is a good basis for subsequent discussions.

The implementation of all other field operations is the responsibility of participating farmers. However, it is advisable that field staff discuss with farmers what operations should be performed before the next visit in order to make sure that the two rules mentioned above are followed and to ensure that farmers neither pay special attention to the trial fields nor neglect them.

After trial **harvest** the produce should be available to farmers in such a form that it can be processed or stored in the usual manner. Farmers who want to store their trial maize unshelled would, for example, usually not accept that all the trial maize is shelled after harvest in order to measure the shelled weight. A sufficiently precise result could be achieved here by by shelling only a sample in order to calculate the shelling percentage. An agreement with farmers about compensation should be made well in advance if it is necessary to remove samples.

Implementing field days

Field days are useful to

- give participating farmers, extension workers and researchers the opportunity to discuss and share experience with regard to the options tested in the trial,
- show the trial to farmers presently not participating
  - for preparation of the subsequent phase of trial implementation or
  - to facilitate discussion with types of farmers under- represented in the on-farm experiments.

– The sharing of experience among farmers and researchers on field days is a good basis for the subsequent trial assessment by farmers.

Presenting trials to farmers not participating in the programme can stimulate their interest and curiosity. Field days are, therefore, particularly useful for acquainting such farmers with a trial, these farmers being potential participants for the next phase of it.

The most appropriate time for field days is somewhere between maximum vegetative development and maturity when both the vegetative and the yield development can be assessed.

Monitoring trials

Frequent monitoring visits by field and professional research staff to trial farmers serve a number of purposes:

- to carry out field observations and record required data;
- to give guidance concerning field operations to be performed;
- to check correctness of field implementation and (this applies to professional staff) of data recording by field staff;
- to discuss trial farmers' views of tested options;
- to motivate farmers and to inspire farmers confidence in the research staff.

All points apply to field staff as well as the professional staff. The professional staff is, of course, also responsible for guiding, supervising and motivating field staff.

Involving extension workers in monitoring visits helps to keep them up-to-date with the progress of the experimentation.

Efficient monitoring requires **frequent visits** to farmers. Visits can be less frequent in verification trials than in exploratory or adaptation experiments.

For **field staff** a regular sequence of visits (for example every two weeks for exploratory or adaptation trials) is recommended between trial layout and harvest. Motivating and communicating with farmers are as important purposes of regular visits by **professional staff** (or supervisors) as the observation of crop performance or the supervision of trial implementation. Visiting trial farmers as often as possible is especially important if intensive communication with farmers or acquiring farmers confidence is essential to the success of the trial.

A schedule of visits for **professional staff and supervisors** for exploratory and adaptation experiments as compared to verification trials is set out in Table 5.13.

Table 5.13: Minimum frequency of visits to trial farms by professional research staff or supervisors

Time of visit	Type of trial	
	exploratory adaptation	verification
Between field layout and planting	•	
Early season (2-4 weeks after planting)	•	
Middle of season	•	•
End of season (4-2 weeks before harvest)	•	
After harvest (4-6 weeks after harvest)	•	
In the season following trial implementation	•	•

Considering the fact that motivating, guiding and communicating are important functions of monitoring visits, trial fields should be visited **in the presence of the farmer** as far as possible. It is therfore advisable to inform farmers in advance about planned visits.

Data recording

The types of data to be recorded were already discussed in Chapter 5.2.8 (data to be collected). Who is to record what data must be decided for trial implementation.

Experience has shown that it is relatively difficult to achieve a complete and correct **recording of data by field staff**.

Data which can be measured or directly observed in the field (e.g. yield data, "supporting data", information on natural environment) are least problematic and most suitable for being recorded by field staff. Incomplete or incorrect recording of agronomic data is, however, often caused by an insufficient comprehension of the significance of certain data with regard to the subsequent trial analysis. Appropriate training as well as guidance and regular data checks by professional staff or supervisors during field visits are, therefore, essential especially if field staff are relatively unexperienced.

Taking notes in a field notebook as a memory aid helps the professional staff during trial analysis as it preserves impressions gained in the field and allows data recorded by field staff to be counterchecked.

With appropriate training field staff will also be able to implement **formal surveys** to evaluate the degree of adoption or of modifications applied by farmers who were previously exposed to trial technologies. Close supervision and spot checks with farmers interviewed can help ensure that the information obtained is completely and correctly recorded. More often than not it has been observed that not farmers' views but those of the interviewing staff are noted down in the questionnaire.

The **"dialogue on innovation"** for farmers' assessment of tested technologies yields deeper insights into farmers views and motives than a formal survey. Such a dialogue must be carried out by professional staff because it requires good communicational skills as well as a sound conceptional background with regard to objectives and contents of the experiment.

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Annex

Annex 5.1: Examples on application of exploratory, adaptation and verification trials in development programmes

Not all "trial types" really need to be applied as a routine in the course of the development of a particular innovation. The course of action and the shape of a particular trial is rather determined by the information required in order to achieve a particular purpose. Sometimes it may be appropriate to carry out different "types" of a trial for different purposes simultaneously. Some of the examples in the following show also that "farmer participation" in an experiment does not necessary mean that all stages of an experiment are carried out "on-farm" at farmers fields.

Example 1
Climbing beans in Rwanda

This example shows that sometimes one single trial can serve diagnostic, explaratory and verification purposes. This was the case for OF-variety trials on beans in Central Africa. Over 100 OF-trials with 5-10 varieties were farmed out to extension projects. The subsequent evaluation of this trials served multiple purposes:

- to asses bean production problems across regions;
- to asses farmers' awareness of these problems;
- to asses the potential for the improvement of bean productivity in various regions;
- to asses farmers' preferences for bean varieties;
- to asses yield potential of a range of selected bean varieties;
- to asses the acceptability of selected bean varieties for farmers;
- to identify extension partners for further research on more complex topics than variety improvement.

As a consequence the trials became one of the most valuable sources of information in the diagnostic work of the respective bean research programme. They were used to target research action to regions with high potential for impact, to guide the breeding programme and finally proved to be an efficient tool for dissemination promising bean varieties. Follow-up studies indicated that varieties which had never been promoted by extension were grown by large numbers of farmers in regions were OF-variety trials had been established.

Example 2
Cowpeas in Kenya (see also Annexes 5.2 and 5.3)

Cowpeas are an important crop in Lamu District, Kenya. Almost every farmer interplants cowpeas into his main crops, maize and cotton. Available cowpea varieties did not appear, however, to be really appropriate for interplanting with cotton. Due to their spreading or semispreading growth habit they often entangled the cotton and interfered with its development. The screening for better adapted cowpea varieties was, therefore, considered an opportunity to improve cotton – cowpea intercropping.

The cowpea screening started with an "**exploratory**" stage. A relatively large choice of cowpea varieties (close to 30) obtained from research stations or locally selected was planted, one plot per site, at two sites representing the range of environmental conditions of the area. Shortly before cowpea maturity farmers were invited to the trial sites in order to asses the varieties. Those varieties assessed favourably by farmers and showing desirable agronomic characteristic (like a reasonable resistance to pests and diseases) were taken into the next step.

In this step the "**adaptation**" of the chosen varieties to interplanting with cotton was tested with a mainly agronomic perspective with a few innovative farmers. Simultaneously a "**verification**" type of trial was implemented, in which a representative choice of farmers was asked to grow a number of varieties according to their own practices and to assess the tested varieties with their own criteria.

Adaptation and verification experiments turned out to be nuclei for a rapid diffusion process of those varieties assessed favourably by farmers.

Example 3
Sesbania for staking of climbing beans in Rwanda

An example for the complementarity of OF- and OS-Trials is a research programme on the simultaneous association of common beans with Sesbania magrantha, an erect type of green manure. The idea is that the two plant types grow together in a randomized pattern according to the traditional farmers planting technique. S.magrantha with it's stems would prevent the bean pods from touchning ground at harvest time of the beans and after harvest stay in the field to cover the soil and produce biomass on residual moisture.

The research questions to be explored in a first phase were:

1. Effects of the assosiation on bean yields with varying planting times and densities of the components.
2. The effect of incorperating S.magrantha into the soil on subsequent crops.
3. The acceptability of the additional labour requirement for farmers.

The first two questions are difficult to inquire in OFT's. The trial designs required are complex and the evaluation of growth pattern of the components time consuming and difficult to be carried out in OFt's.

In turn, it is difficult to get a reasonable assessment of farmers' reactions to additional labour requirements without OFT's. Hence, it was decided to work simultaneously on-station to explore questions one and two and on-farm for question three. Both types of trials are of exploratory nature but carried out in different environments according to the objective of the trial.

Example 4
Techniques for maintaining soil fertility in Kenya

Farmers in Lamu District, Kenya, viewed decreasing soil as a major threat to agricultural production. Knowledge about techniques to maintain soil fertility was, however, rather limited with farmers. Extension workers and researchers were, on the other hand, uncertain with regard to the question which techniques would be appropriate under the natural and socioeconomic conditions of the district.

In an **exploratory** step it was tried, therefore, to create and assess a relatively wide range of sample types of technology, like planted fallow with different fallow crops, alley cropping with different tree species (like Leucaena leucocephala, Calliandra calothyrsus etc), integration of trees like Acacia albida or Grevillea robusta into cropped fields, intensive intercropping using vegetavively vigorous grain legumes (e.g. Dolichos beans, Lablab purpureus), etc.

The exploratory trials at a station like experimental site under management of research staff. Some of the reasons for this decision were:

- the uncertainty about results to be expected;
- the likelyhood that positive results would show, if at all, only after several seasons and, related to this,

– the probabilty that farmers, who have not seen yet an example of the technology at work, would not be motivated enough to take care of an on-farm trial for a couple of years until results are visible.

The exploratory experiments were run, on the one hand, to observe the effects of the tested technologies in agronomic terms. On the other hand they were used as a basis for farmer assessment during annual fielddays usually attended by several hundreds of farmers. To keep the programme as broad but as simple as possible every "type of technology" was tested only at one representative site. Collection of agronomic data was kept at a minimum as it was assumed that a practice for soil fertility maintainance would have to show easily visible effects in order to arouse farmers interest.

None of the tested technologies went into a further stage before farmers mentioned their interest in trying it out themselves. Intercropping of Dolichos beans with maize, a practice not unfamiliar to farmers, spread rapidly amongst farmers already in the exploratory stage of the experiments. It is hard to judge, however, how far this was an effect of the trial programme. "Exotic" technlogies were viewed rather sceptical by farmers until positive effects began to show. This took often some years, if effects got apparent at all.

An example for such an "exotic" technology was alley cropping. Those farmers keeping livestock, like small ruminants or cattle, developed an interest in alley cropping with leucaena relatively fast, as it got apparent soon that this practice was an opportunity to combine production of fodder and other crops. The interest of other farmers in alley cropping arose only after 4 seasons when soil fertility effects began to show in the leucaena treatment. Presently **"adaptation"** type of trials are undertaken with farmers who wanted to try out themseleves. The primary aim is to adapt alley management practices (like cutting and pruning of trees) to farmers resources and work calendar.

Annex 5.2: Examples of "trial protocols"

Written "trial protocols" are an important reference material for field staff during trial implementation. They contain basic advice on trial layout, treatment application, field operations and trial monitoring. The following shows "trial protocols" used for some of the "trial types" described in Annex 5.1.

Example 1 contains the trial protocol for an **"adaptation"** type of experiment on cowpeas. The experiment investigates the adaptation of different cowpea varieties to interplanting with cotton at different soils. The experiment puts emphasis on collection of agronomic data. A detailed description of field operations and trial layout is given. Important field operations are defined, the field layout is fixed and the data collection is relatively detailed.

Example 2 contains the "trial protocol" for a **"verification"** type of trial on cowpeas. The experiment is mainly run for the farmer assessment of cowpea varieties. The major "input" of the researcher is the provision of seeds and some recommendations on how the seeds could be planted. Field operations and field layout are, however, decided by farmers themselves. A detailed description is, therefore, not required. Data collection is less detailed as in the "adaptation" trial (see Annex 5.3).

The description of **Exploratory** experiments can be as detailed as that of the adaptation trial or as shallow as that of the verification trial. How well treatments and other field operations are defined in the "trial protocol" depends on what kind of information is to be gathered and how far farmers themselves are supposed to take over management responsibilities.

Example 1
Trial protocol for an "adaptation trial"

Trial title: **Suitability of Cowpea Varieties for Interplanting with Cotton**

File name: CPVRICCT

Objectives:
(1) to test a range of preselected cowpea varieties with regard to their suitability for interplanting with cotton under different soil conditions;
(2) to assess how these varieties meet farmers preferences;
(3) to identify an appropriate time of cowpea interplanting.

Site: Lake Kenyatta Settlement Scheme

Farmers: 4 farmers on red loam soil,
4 farmers on sandy soil.

Important selection criteria:

- farmers are experienced in cotton/cowpea intercropping;
- farmers are keen on testing new varieties;
- the chosen field is cultivated with cotton and copweas anyway.

Treatments: 4 cowpea varieties and 2 times of cowpea planting:

Varieties:
(1) K 80
(2) M 66
(3) LK 577 erect
(4) Farmers own

Times of interplanting:
t1 cowpeas planted at farmers own time
t2 cowpeas planted 3 weeks after cotton

Non treatment factors:

all operations apart from "cowpea varieties" and "time of interplanting" are implemented according to farmers' usual practice;

Cowpeas can be interplanted into cotton or into cotton/maize. The decision about the cropping system is taken by farmers.
Suggested within the row spacing for cowpeas is 45 cm between stations with 2 plants per hill.

Inputs provided: Cowpea seed

Layout: The trial follows a randomized complete block design with 6 treatments (see layout plan)

Layout plan:

LK 577 t 1	M 66 t 2	K 80 t 2	Farmers t 1	
K 80 t 1	Farmers t 2	LK 577 t 2	M 66 t 1	9,0 m
		8 cotton rows		

Data to be recorded: The following record forms are provided:

(1) the "trial report";
(2) the "harvest record form" and
(3) the "farmers' assessment form" (→ Annex 3).

Plot size: **Gross:** 8 cotton rows (approximately) 7 m x 9 m

Net: Measurements and observations are done for the net plot only.

1 cotton row at each side of a plot and 1 cotton station at the beginning and the end of every cotton row are discarded to get the net plot.

Note: Plot sizes will differ from farmer to farmer because cotton spacing is decided by farmers. Therefore actual net plot sizes need to be recorded in the "trial report".

Example 2
Trial protocol for a "verification trial"

Trial title: **Cowpea Variety Assessment**

File name: CPVRASS

Objectives: The trial is implemented in order to obtain an assessment of promising cowpea varieties by a representative group of farmers.

Sites: Lake Kenyatta, Hindi-Magogoni and Witu Settlement Schemes.

Farmers: At least 10 farmers per scheme will be chosen to participate in this trial.

Treatments: 3 cowpea varieties

(1) K 80
(2) M 66
(3) 577 erect (local selection)

Procedure:

The participating farmers will be supplied with 250g seed of every Cowpea Variety. They will be given advise on how to cultivate the different varieties. The **cultivation is, however, left entirely to the paricipating farmers**. The farmers are asked to **grow their own varieties for comparison.**

There is **no formal trial layout applied**. Arrangement and cropping system is chosen by participating farmers.

Farmers are asked to return 250 g of every variety after harvest.

Monitoring/Data recording:

The participating farmers are visited at the time of planting and monthly during the growing periode of the crop to monitor cultivation practices applied and crop development. Field observations are recorded in the "trial report" form (→ Annex 5.3).

Before crop maturity farmers meetings are done to show the varieties to neighbouring farmers in order to discuss crop performance and compatibility of the varieities with farmers preferences.

After harvest participating farmers are asked for their assessment of the tested varieties. Results are noted in the "farmer assessment" form (→ Annex 5.3).

Annex 5.3: Sample record forms

The following shows sample record forms as they were used by the German Assisted Settlement Programme in Lamu, Kenya.

Record forms 1, 2 and 3 were used for data recording in an **adaptation trial** on cowpea varieties:

Record form 1 contains information which helps eventually in the interpretation of experimental results, like information

- on the environmental setting of the farm;
- dates of key field operations;
- some phenological observations;
- observations on management, soil differences, pests & diseases etc.

Record form 2 is used for recording of harvest data. Different crops may require different harvest rcord forms.

Record form 3 is used for recording of rainfall data.

For **verification trials** recording should be much less detailed than for adaptation trials. All the information desired with regard to environmental setting and field observations is contained in one record form (s. Sample record form 4).

Sample record form 5 was used for the recording of the **farmer assessment** of cowpea varieties after the trial harvest. Similar forms will be appropriate for both, adaptation as well as verification experiments.

Detail and nature of data recording in **exploratory trials** depends on the question to be answered by the trial. The focus can be more on field observations and measurements, if the critical questions are of agronomic nature. The focus will be on farmer assessment if the experiment is to answer mainly questions of socioeconomic nature.

Sample Record Form 1: "Trial Report" – Adaptation Trial

Page 1

On-Farm-Trial – Trial Report

Suitability of Cowpea Varieties for Interplanting with Cotton

Site: Lake Kenyatta Settlement Scheme **Season:** 1992

Reporting Officer: ____________________

Farmers Name: ____________________ **Plot No.:** __________

Farm Size (Ha cultivated area): ____________________

Off Farm Employment (yes/no): ____________________

(1) General Data

– Soil type: ____________________

– Cropping system applied: Cotton/Maize/Cowpea ☐ Cotton/Cowpea ☐

– Actual plot size: Gross: __________ Net: __________

(2) Dates of field operations:			
– planting:	Cotton:	Cowpeas:	Maize:
– weeding:			
– fertilizer application (type of fertilizer, amount and dates)			
– pest control measures (type of chemical, dates of application)			

Page 2

(3) Data on crop development:				
Cowpea data:		K 80	M 66	LK 577
– Start of flowering:				
– Harvest	– from:			
	– to:			
Harvest Cotton		from:	to:	
Harvest Maize (if applicable)				

(4) Assessment by reporting officer:

Assess quality of crop management: ____________________

How did soil differences affect trial? ____________________

How did pests and diseases affect trial? ____________________

Any irregularities during trial implementation? ____________________

Anything else to be reported? ____________________

(use back of this page if the space is not sufficient)

Sample Record Form 2: "Harvest Record" – Adaptation Trial

Harvest Record Form – On-Farm Trials Crop: Cotton

Trial Type: ________________ Season: ________________________

Site: ______________________ Dates of harvest: ________________

Farmer Name	Rep. No.	Plot No.	Treat-ment	Net Plot (m^2)	Vacant Stations	No. of Plants	Total Weight	AR (kg)	BR (kg)	

Harvest Record Form – On-Farm Trials Crop: Cowpeas

Trial Type: ________________ Season: ________________________

Scheme: ________________ Dates of harvest: ________________

Farmer Name	Plot No.	Trial Plot No.	Treat-ment	Net Plot (m^2)	Vacant Stations	No. of Plants	Weight unshell.	Mois-ture (%)		

Sample Record Form 3: Rainfall Record Form

Site: ____________ Season: ____________

Reporting Officer: ________

Month/ Day	April	May	June	July	August	Sept.	Oct.
1							
2							
3							
4							
5							
:							
:							
:							
26							
27							
28							
29							
30							
31							
Sum 1-10							
Sum 11-20							
Sum 21-31							
Total							

Sample Record Form 4: Verification Trial

On-Farm-Trial – Cowpea Variety Observation Page 1

Trial Record

Village: ____________ **Season:** ________

Reporting Officer: ____________

Farmers Name: ____________ **Plot No.:** ________
(if applicable)

Farm Size (Ha cultivated area): ____________

Off Farm Employment (yes/no): ____________

(1) General Data:	
Soil type:	
Year of bush clearing:	
(2) Cowpea Data: (approximate dates of:)	
– planting:	
– start of flowering:	
– harvest (from – to):	

(3) How were cowpeas planted: Pure stand: ☐

Intercropped: ☐

(4) If intercropped, which were other crops? ____________

____

What was the spacing for these crops? ____________

____

Page 2

(5) Estimate spacing for cowpeas: ______________________

____

(6) Assessment by reporting officer:

Assess quality of crop management: ______________________

____

____

How did pests and diseases affect the cowpeas? ______________

____

____

Compare performance of the cowpea varieties: ______________

____

____

Anything else to be reported? ______________________

____

____

____

Sample Record Form 5: Farmer Assessment after Trial Harvest

Cowpea Variety Observation – LKSS 1991 Page 1

Variety Assessment by Participating Farmers (please ask questions in the given order)

Name of Farmer: ______________ **Plot No.:** ________

Date of interview: ______________________

(1) Ask farmers to describe characteristics and performance of the tested Cowpea varieties in their own words:

K 80: ______________________

____

____

M 66: ______________________

____

____

Local 577: ______________________

____

____

Own variety: ______________________

____

____

(2) How does farmer rank the quality of the tested varieties with regard to the following characteristics:

- growth habit (1) ____ (2) ____ (3) ____ (4) ____
- time to maturity? (1) ____ (2) ____ (3) ____ (4) ____

Page 2

- pest infestation in the field? (1) ____ (2) ____ (3) ____ (4) ____
- yield? (1) ____ (2) ____ (3) ____ (4) ____
- grain size? (1) ____ (2) ____ (3) ____ (4) ____
- grain colour? (1) ____ (2) ____ (3) ____ (4) ____
- storability? (1) ____ (2) ____ (3) ____ (4) ____
- cooking time? (1) ____ (2) ____ (3) ____ (4) ____
- taste? (1) ____ (2) ____ (3) ____ (4) ____

(3) Is there any other important condition a variety should meet? ____

____

- what is the ranking with regard to this condition?

(1) ____ (2) ____ (3) ____ (4) ____

(4) What is the overall ranking of the varieties, considering all their advantages and disadvantages?

(1) ____ (2) ____ (3) ____ (4) ____

(5) Does the farmers intend to plant any of the tested varieties on his own farm in 1992?

Yes ☐ No ☐

a) if yes, which varietie(s)? ____

b) if yes, reason for his choice? if no, why not? ____

____

Chapter 6 Tools and methods for data analysis and presentation

Chapter 6 Tools and methods for data analysis and presentation

The raw material for the analysis of data comprises a multitude of information contained in questionnaires or record forms. This information must be organized and prepared for data processing, processed, and eventually compressed and represented in a form that can be used to draw reasonable conclusions with regard to the subject under examination.

Some kind of data analysis will be required for the exploration of demand for innovation as well as to identify available options and finally to assess tested options. The different nature of data collection methods was explained in Chapter 4. The non – formal or the formal character of the data collection will also determine the mode of data analysis.

6.1 Analysis of information from non-standardized data collection

The analysis of information from non-standardized data collection, for example information gained from dialogues on innovation or from exploratory surveys, is of descriptive nature. The analysis seeks to summarize a multitude of individual pieces of information and to deduce common tendencies and interrelationships. For example, it can produce:

- a description of farming systems, including farmers goals and preferences as well as background conditions and their influence on the development of farming systems;
- a description of the criteria an innovation must meet to satisfy farmers goals and preferences or to be compatible with environmental and socioeconomic conditions;
- an assessment, before or after experimentation, of the extent to which potential innovations coincide with farmers goals and preferences.

The analysis of information from non-standardized data collection will usually not yield quantitative and representative results. The results have therefore more the character of hypotheses. Verification through standardized data can be required if these hypotheses significantly influence the direction of a programme and the validity of a hypothesis is doubtful. Verification is advisable in any case in the final stage of research, in order to demonstrate the correspondence of an innovation with farmers' goals and preferences.

There are no standard routine procedures for the analysis of information from non-standardized data gathering. The following can only contain a collection of methods that have been successfully applied in the development of agricultural innovations. Every situation requires its own procedures. The examples are meant to stimulate the development of the readers' own methods, adapted to the specific project situation.

All methods described can be used right in the **dialogue with farmers** to help them structure their experiences and ideas.

The result of the analysis is not intended to be a comprehensive description of farming systems and their framework conditions. The aim is rather to highlight out key issues which are expected to have a bearing on the direction of the programme.

6.1.1 Cropping patterns

Diagrams, as they are shown in Figures 6.1 and 6.2 are a simple aid for visualizing the **distribution of crops in terms of space and time** in a readily understandable form.

Frequency distributions can be used to visualize **land use patterns**. Graphical aids often used are cross tabulations (see Table 6.1), pie charts (Figure 6.3) or bar charts (Figure 6.4).

Different reference frames are possible: land use patterns are often shown as an average for all farmers in a project or a specific geographical region. It will be helpful with regard to the programme design, however, if the land use pattern is related to **critical ecological** (e.g. soils, rainfall, etc.) **or socioeconomic parameters** (e.g. available land or labour etc.).

A **transect** through a defined zone (i.e. a geographical area, a watershed, a village or a farm) as shown in Figure 6.5 helps to relate simple information on land use pattern to critical factors of the respective microenvironment. This tool can be used by researchers in order to summarize information collected. It was moreover successfully applied in dialogues with farmers in order to discuss the ecological features of an area.

Figure 6.1: Diagram of the spatial arrangement of a three-crop mixture in northern Ghana (Steiner, 1984)

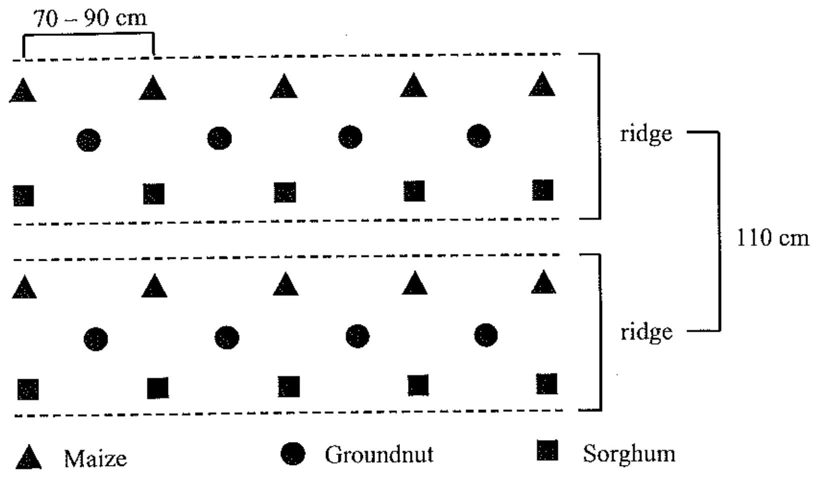
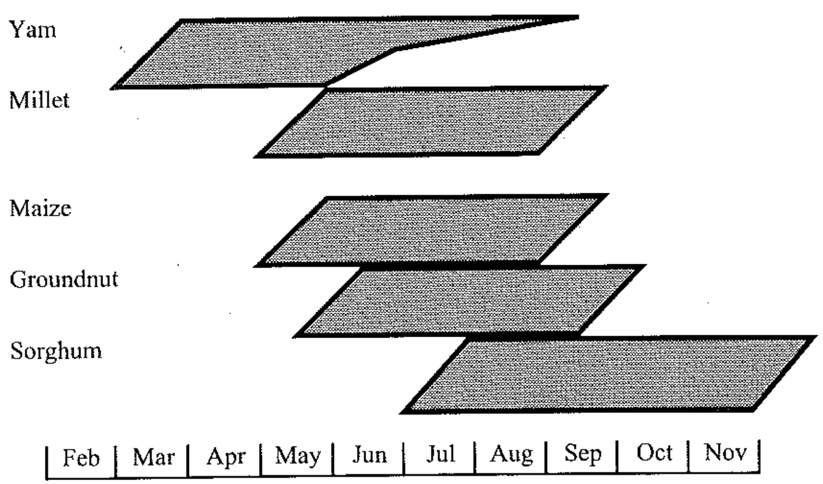


Figure 6.2: Diagram of principal cropping sequences identified during an exploratory survey in northern Ghana (adapted from Steiner, 1984)

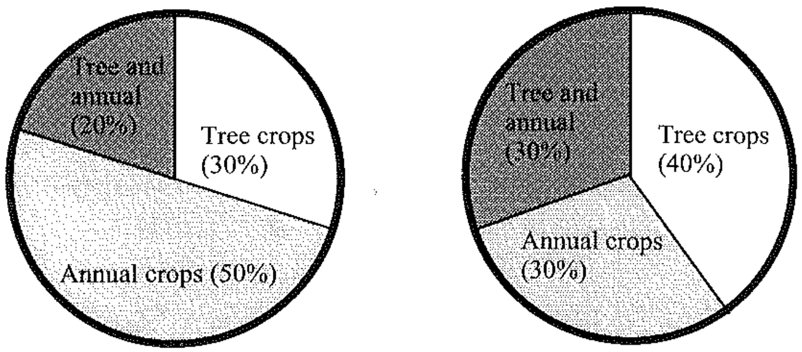


Different tools can be used to analyze **historical developments**. The **bar chart** in Figure 6.4 shows the development of land use patterns. **Historical transects** are developed in the same way as geographical transects. The analysis of historical developments reveals already ongoing tendencies. These are often farmers responses to existing production constraints or changing circumstances. This kind of analysis can help to detect system constraints or to ask the right questions. Programme activities will be, furthermore, more promising if they have a direct bearing on already ongoing developments.

Table 6.1: Cross tabulation of land use pattern at Lake Kenyatta Settlement Scheme (Kenya) by dominant soil types, estimated % of cultivated area (adapted from Neunfinger, Schmale and Werner, 1987)

Type of cropping system	red loams (on coral reef)	sandy soils (Kilindini sand)
Tree crops pure stand	30	40
Annual crops pure stand	50	30
Tree crops + annual crops	20	30

Figure 6.3: Pie chart of land use patterns at Lake Kenyatta Settlement Scheme derived from tab. 6.1



a) red loam soils b) sandy soils

Figure 6.4: Bar chart (stacked bar) of past development of land use patterns at Lake Kenyatta Settlement Scheme

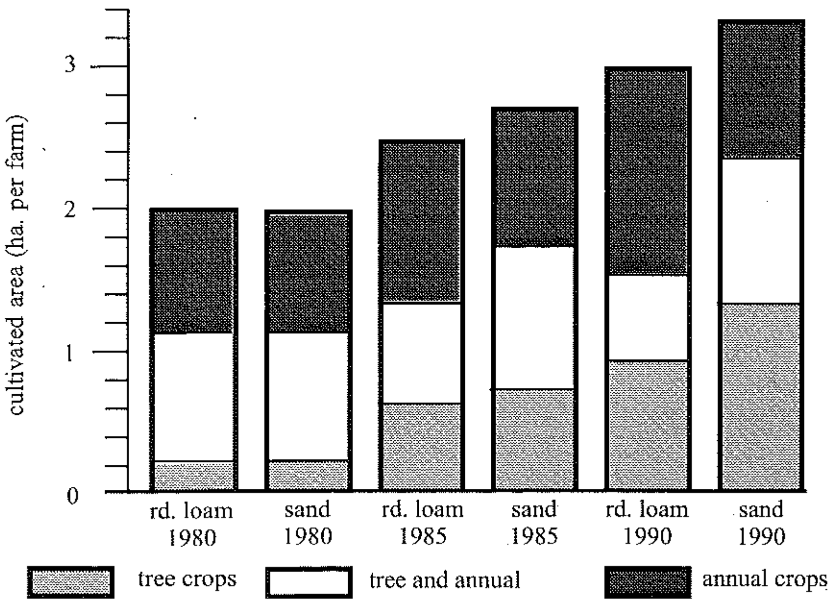
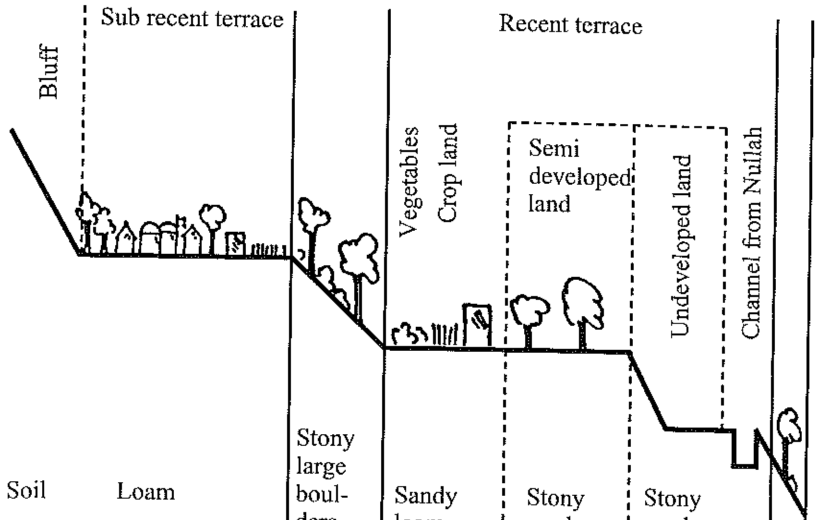


Figure 6.5: Transect of a village in northern Pakistan (Source: Conway, 1989)



Soil	Loam	Stony large boulders	Sandy loam	Stony sand	Stony sand	
Crops	Wheat-Maize, Mash Wheat-Fallow Vegetables Potatoes	Bushes trees	As for recent terrace	Willow Poplar Russian Olive Thorny Bushes	Scattered trees	
Livestock	Ruminants Free grazing in winter	Grazing	Free Grazing	Grazing		
Problems	Pod borer in mash Water flooding from can. Water shortages	Poor soil	Serious water shortages	Poor soil	Flooding	
Opportunities	Pest control Extend canals-irrigation and water control		Improve grazing, extend canals	More trees	Alfalfa irrigation	

6.1.2 Seasonal calendars

Seasonal calendars are diagrams which graphically present seasonal features. They are useful for the identification of system constraints. They help to assess the feasibility of potential innovations. Sometimes they also reveal times of the season which could be more efficiently used.

A calendar starting with a key event of the season (like the beginning of land preparation or the onset of the rainy season) is more appropriate than the conventional calendar beginning with January.

Most useful and common are representations showing the development of the following factors in the course of the seasons:

- climatic factors;
- cropping patterns;
- labour demand or availability for farm work;
- off farm employment opportunities;
- key events with regard to livestock production;
- prices for crops, livestock or food;
- availability of food, etc.

Figures 6.6 to 6.8 present some examples:

Figure 6.6 illustrates critical climatic features of an area in Malawi, in this case rainfall, which also includes the onset and end of the rainy season, and the probability of dry spells within the rainy season. Similar representations can be used to show the development of temperature, evaporation, etc in the course of the season. Information obtained from farmers can yield relatively reliable semi-quantitave estimates in the absence of measured data.

Figure 6.7 shows a labour allocation profile for selected crops from a project area in Kenya. The semi-quantitative representation reveals which crops compete for labour at which time of the year. If it is related to the land use pattern it helps to identify periods in which labour is highly demanded or labour slack periods. It helps to identify unused opportunities if it is considered in relation to critical climatic features and to price developments at the local market; etc.

Figure 6.8 synthesizes a number of critical seasonal features for a village in northern Pakistan.

Figure 6.6: Seasonal calendar of critical climatic data, (Liwonde ADD, Malawi)

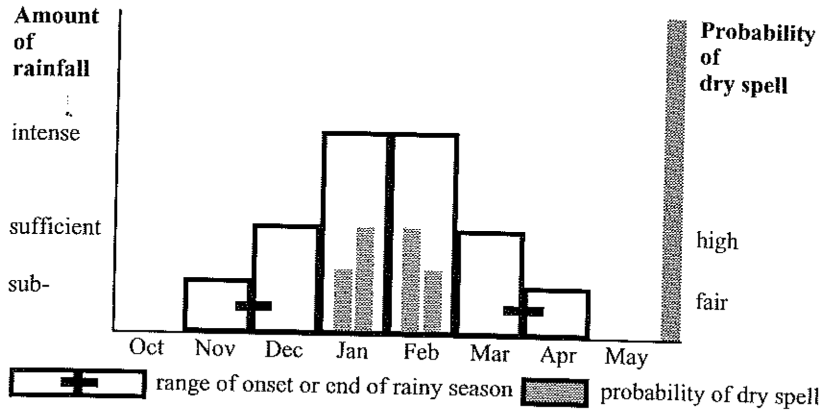


Figure 6.7: Labour allocation profile, Lake Kenyatta Settlement Scheme (Kenya), (adapted from Neunfinger, Schmale and Werner, 1987)

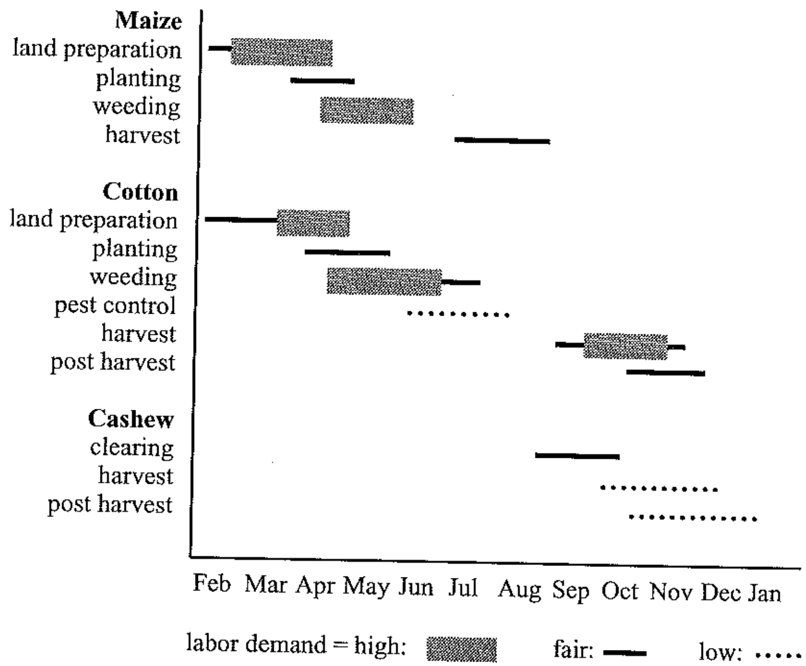
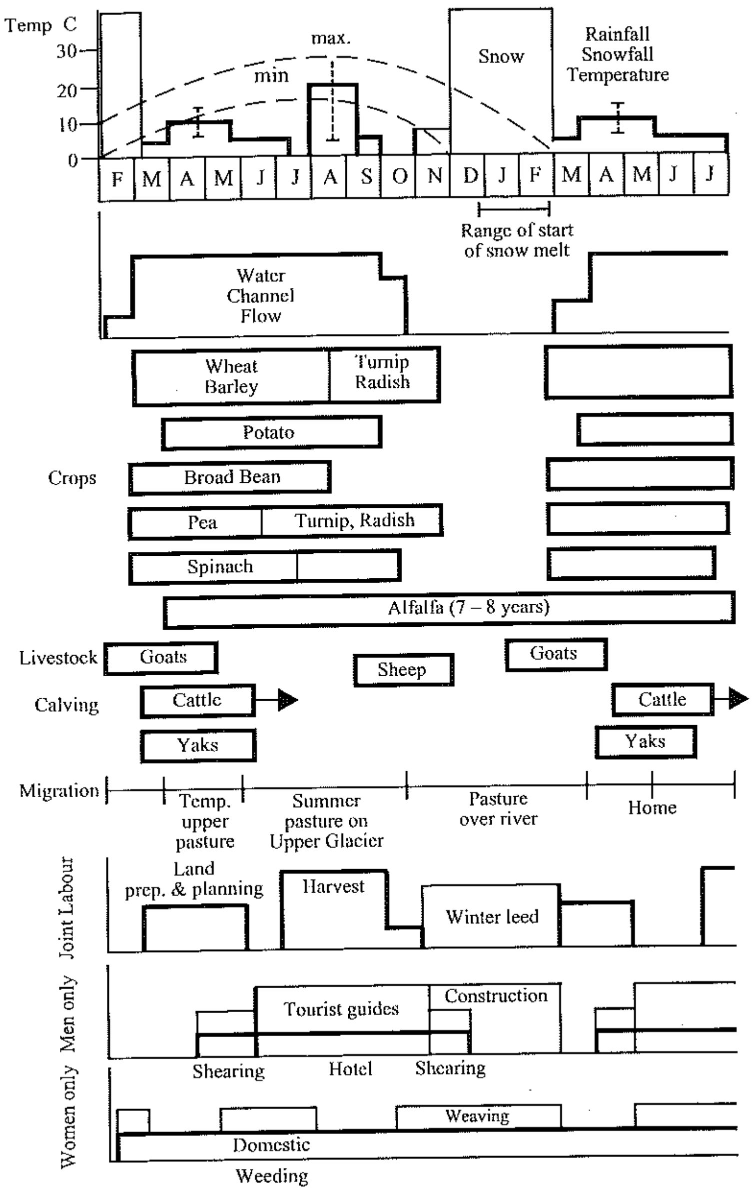


Figure 6.8: Seasonal calendar for a village in northern Pakistan (Conway, 1989)



6.1.3 Definition of "target groups"

Every farmer has his own particular goals and works under different circumstances from his neighbour. It is therefore hardly accurate to consider "farmers" as a homogeneous undifferentiated mass in programme planning and implementation.

Target grouping helps to strike a balance between two extreme alternatives: (a) to develop recommendations for each farmer (impossible), and (b) to develop one recommendation for the whole farming community despite differences in farming systems and determining goals and circumstances (inappropriate). The number of target groups defined will depend on the amount of variation in farmers circumstances (the more variation, the more groups) and the amount of research resources (the more resources, the more groups can be afforded).

Purpose of target grouping

"Target grouping" divides the heterogeneous farming population into more homogeneous subgroups on the basis of those factors which determine the farming systems (like natural and socio-economic circumstances, goals and preferences etc). It is not done for its own sake, but in order to identify differences between and highlight similarities within groups which are significant with regard to the development of agricultural innovations. It is therefore essential not only to identify differences between groups of farmers, but also to analyze how these determine farming systems or practices and opportunities for their improvement.

Target grouping can be done at different levels of the project work

The **general target group analysis** of a project decides which group of people the project is going to support. This target group definition also determines what kind of farmers are to participate in the research efforts. This definition is, however, often too broad and unspecific for research purposes.

Often it is only a particular group of farmers within or across the target groups defined in the general project target group analysis which suffers from a particular problem or which has a specific potential. For this reason it is rather required to characterize subgroups of farmers (called "recommendation domains" by CIMMYT) **specific to an identified problem or potential or to an innovation to be tested**, i.e. groups of farmers which

- are affected by the same production problem, or
- have a particular potential that is not yet utilized, or
- are likely to adopt a specific innovation developed.

This kind of problem, potential or innovation specific "target grouping" helps

- to determine in the analysis of demand for innovation whether the significance of the target group justifies the development of an innovation;
- to analyze whether a potential innovation matches with the requirements of the target groups during the identification of options;
- to select appropriate farmers belonging to a relevant target group for participation in the experimentation programme, and
- eventually to evaluate whether the developed innovation was adopted by its target group or how it was adapted by the target group to its specific conditions.

Procedure

No universally applicable recipe can be given for the identification of different target groups. A workable approach for target grouping appears to be a stepwise one as shown in Figure 6.9, looking successively for differences between groups of farmers with regard to natural conditions, socio-economic circumstances and goals and priorities.

A list of criteria useful for target grouping shown in Table 6.2 gives some guidance. In the target group analysis the aim should be to determine a few (3-5) obvious key characteristics that differentiate different groups of farmers rather than to apply a comprehensive list of criteria.
(Annex 6.1 provides a detailed example of target grouping.)

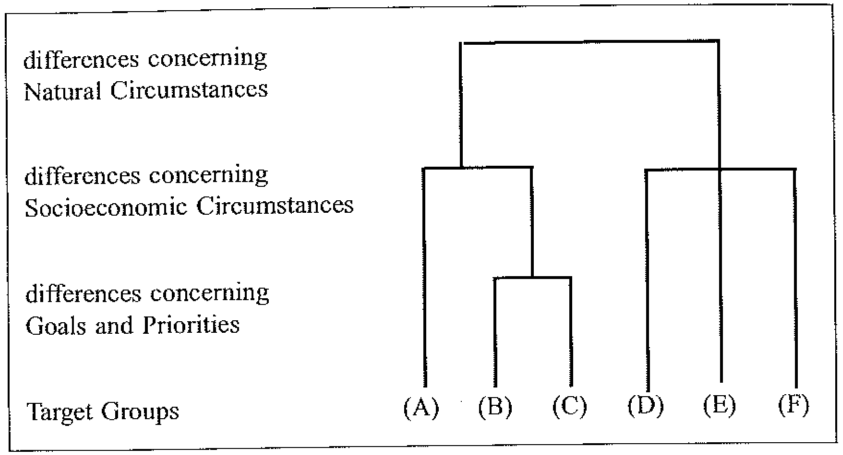
Table 6.2: Criteria useful for target grouping (adapted from CIMMYT, 1985)

Natural conditions
- climate
  - rainfall (duration, distribution, intensity, risk of drought, risk of flooding);
  - temperature (frost incidence);
- soil
  - nutrient supply capacity;
  - texture, structure;
  - drainage, slope, depth;
  - toxic elements, salinity;
- biology
  - pest / disease / weed incidence.

Socio-economic circumstances
- access to land; land tenure;
- access to produce and input markets;
- access to family / hired / shared labour;
- off-farm and non-farm employment;
- access to cash;
- access to credit;
- access to irrigation;
- degree of farm mechanization;
- community customs and obligations.

Goals and priorities
- food preferences;
- income targets;
- risk aversion;
- social objectives.

Figure 6.9: Distinguishing target groups



6.1.4 Analysis of problems and potentials

Problems and potentials are analyzed either
- in group discussions within the dialogue on innovation with farmers or
- as a component in the synthesis of the exploratory survey.

The contents of an experimentation programme should be the **logical and evident consequence** of the analysis of demand for innovation.

The following five steps have proven to be a suitable approach to analysis:

(1) **"Brainstorming"** = list agricultural problems and potentials;
(2) **"Screening"** = check and streamline the initial list;
(3) **"Digging deeper"** = look for more information;
(4) **"Defining target groups"** = define which farmers have a particular problem or potential;
(5) **"Ranking"** = assess the importance of a particular problem or potential.

(1) Brainstorming

In the first step a "brainstorming" session is held to draw up a list of agricultural production problems and of potentials which are not utilized. The aim is to make as **comprehensive a list** as possible. The relevance or importance of a problem or potential are not considered at this stage. (→ Example 6.3)

(2) Screening

The aim of this step is to streamline the initial list and to improve the phrasing of the statements.

During the screening the following questions are asked:
- whether the statements are appropriate and understandable;
- whether the statements can be formulated more specific;
- whether all problems are within the reach of the given means;
- whether there are any repetitions.

(see Example 6.4)

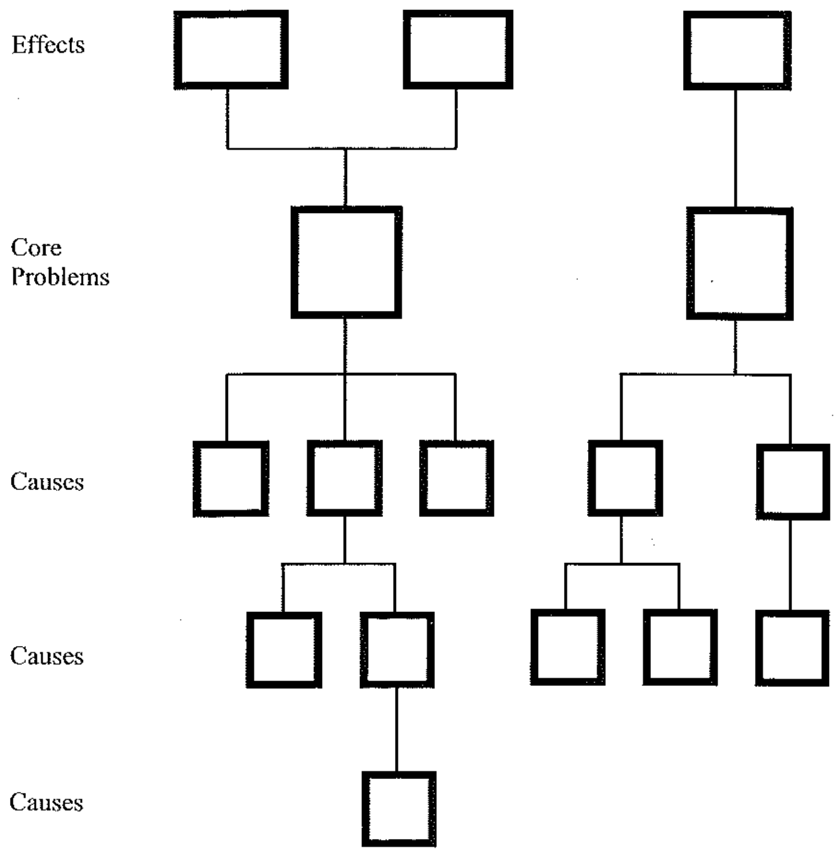
(3) Digging deeper

The aim of this stage is to find **leverage points** for the identification of available options which appear to be suitable to solving a problem or utilizing a potential.

The statements in the list of problems and potentials will usually not show the direction of potential options. It will therefore be necessary to look deeper into the **causes** of the identified problems and to seek **factors** that justify the assumption that there is a potential which could be better utilized. A **comprehensive analysis** ensures that the subsequent steps lead in the right direction.

The results of this step are set out in a **problem tree** (see Figure 6.10) **or summarized verbally**. Elaborating a problem tree in a group discussion requires specific skills on the part of both moderator and participants. A verbal summary is more easily achieved especially in discussions involving farmers and field level staff (see Example 6.5).

Figure 6.10: Graphic presentation of cause-problem relationships using a "problem tree"



(4) Defining target groups

"Target grouping" at this stage defines groups of farmers which are affected by a particular problem or which have a specific potential. An appropriate "target grouping" will help:

- to assess the significance of an identified problem or potential in respect to the importance and relevance of the target group;
- to involve the relevant group of farmers in the subsequent steps of the work.

Principles and procedures of target grouping are explained in detail in Chapter 6.1.3 "target grouping".

(5) Screening and ranking of problems and potentials

A good dialogue with farmers or a thorough farming systems diagnosis will produce a list of problems and potentials too big to be addressed by a trial programme.

The problems and potentials identified must therefore be arranged in order of priority on the basis of the criteria defined in a "dialogue on innovation" in order to select options for experimentation. The criteria should take account of factors such as:

- the importance of the target group in question (i.e. what is the proportion of the target group to the total population?);
- the importance of the respective crop or farm activity within the farming system
- the importance of the problem or potential as it is viewed by farmers
- the significance of the problem or potential in terms of income or subsistence, as it is viewed by researchers.

A matrix as shown in Figure 6.11 can be used for this step. The final ranking of the importance of a problem should be thoroughly thought through and discussed, and not just based on a mechanical addition of the individual rankings of the different aspects considered.

Figure 6.11: Sample matrix for ranking problems (adapted from Tripp and Woolley, 1989)

Problem or potential	Target Group Definition	Criteria					Relative Importance of problem/potential (rank)
		Significance of Target Group	Importance of Crop/ Enterprise	Significance of Yield of Income Loss	Significance felt by Target Group	(?)	

xx = very important x = important o = unimportant

6.1.5 Assessment of potential options before experimentation

The assessment of potential options before experimentation addresses two questions:

- the definition of criteria an innovation needs to comply with and
- the screening of potential options for experimentation.

The most appropriate tool for this analysis is the dialogue on innovation with panel or group discussions with potential target groups.

Definition of criteria for screening of potential options

The basis for this activity is a **brainstorming** session with farmers, which results in a **list of criteria**. If it is considered necessary, researchers may add to the list of criteria suggested by farmers.

A comprehensive list usually requires a **rating or prioritizing** of the identified criteria (a) because the various criteria will be of different importance and (b) because it is impractical to work with a list which is too long in the subsequent screening of options.

A simple tool for rating and prioritizing is a rating scale as it is shown in Figure 6.12. The rating scale translates (subjective) attitudes into a numeric form. This permits a researcher to assess and compare the relative importance of the different chosen criteria. A scale using about 5 grades allows, on the one hand, some degree of differentiation and does not, on the other hand, exceed the ability of participants to differentiate.

The rating of the criteria is used (a) to organize the criteria in order of their importance and (b) to eliminate those criteria which are considered less important. An appropriate list for the subsequent screening will eventually contain 5 up to 10 key criteria – the higher the number of potential experimental treatments, the lower the number of criteria to be applied.

Figure 6.12: Rating scale for screening of cowpea varieties

	very important		fairly important		not important
	(2)	(1)	(0)	(–1)	(–2)
does not fall apart at cooking	❑	❑	❑	❑	❑
tasty leafs	❑	❑	❑	❑	❑
high yield	❑	❑	❑	❑	❑
drought resistance	❑	❑	❑	❑	❑
red grain colour	❑	❑	❑	❑	❑
compatibility with cotton	❑	❑	❑	❑	❑
•					
•					

Screening of potential options

The developed list of criteria is used for the screening of potential options for experimentation.

Where examples of potential options are available already (for instance at research stations), they can be used for a screening exercise involving farmers. Most appropriate are again the tools of the dialogue on innovation, using groups or panel groups of farmers.

The final screening is done by the research team. Those screening criteria which were not important to farmers but crucial in view of the researchers are to be added here. Often not mentioned by farmers are criteria pertaining to sustainability, effects on the local produce markets, sufficiency of research resources etc (further examples of screening criteria were given in Chapter 2.4.2).

A simple tool to compare different options for experimentation is the **matrix technique** shown in Table 6.3. The different options identified potentially useful in solving a specific research question are indicated on the x – axis of the matrix. The screening criteria are indicated on the y – axis, from top to bottom in order of their importance. Different symbols (like +++, ++ and +) show the correspondence of an option with a specific criterion.

The final ranking of the different options or the decision about the activities to be initiated is shown on the last line of the matrix.

Table 6.3 shows a decision matrix as it was developed by the Bean Improvement Project in the Great Lakes Region of Africa. The final decision (last line of the matrix) about the activities to be initiated was based on a thorough discussion of advantages and disadvantages and not on a mechanical addition of the individual ratings given to the different technologies. Eventually "NPK-fertilization and foliar application of fungicides were dropped as options because of the high level and costs of inputs needed for success" (Graf, 1991). Uncertainty (→ climbing beans) was, on the other hand, not considered a reason to drop a topic from the agenda but rather to initiate exploratory activities. Climbing beans, initially burdened with some questionmarks, eventually turned out to be the biggest success.

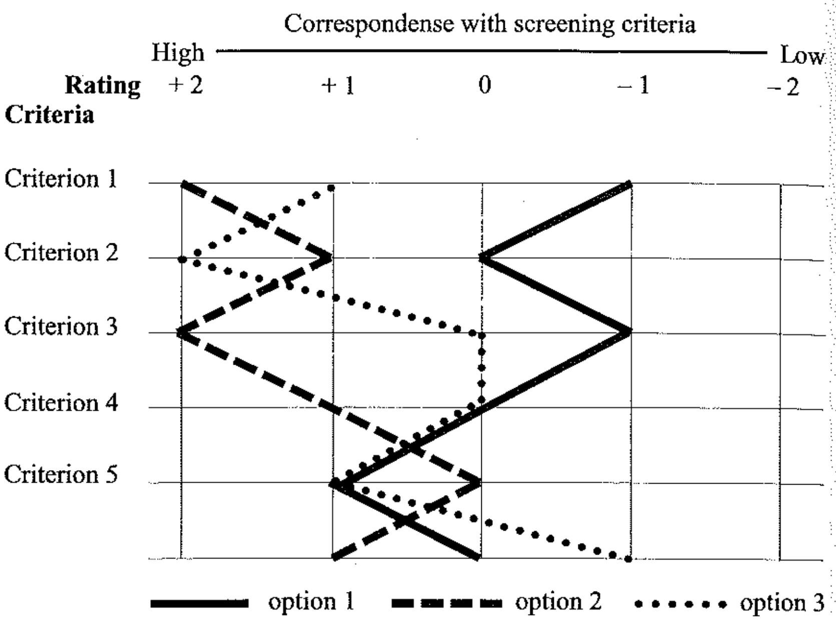
Table 6.3: Decision matrix for " screening of potential research options for the improvement of bean production in Rwanda, 1986" (adapted from Graf, 1991)

Criteria:	Options				
	Climbing Bean	Disease resist. bush beans	Seed treatment bean fly/root rot	Foliar applic. of fungicides	NPK Fertilizer and Manure
The option controls[(1)]	D + (F)	D	P + D	D	F
Chance of success[(2)]	?	+ +	+ + +	+ + +	+ +
Ease of carrying out research	+ +	+ +	+ + +	+ +	+ +
Compatibility with farm. system	?	+ + +	+ + +	+ + +	+ +
Required inputs / institut. support	+ + +	+	+ +	+	+
Profitability	+ +	+ +	+ +	+ +	+ +
Stability	+ ?	+ +	+ +	+	+
Decision[(3)]	OF-study	Continue OS/OF	OS/OF	Drop	Drop

(1) D = Diseases, P = Pest, F = Fertility
(2) + + + = good/favourable, + = poor/unfavourable, ? = uncertain
(3) OS = On-Station, OF = On-Farm

A graphical technique to compare the different options is the **profile diagram**, as shown in Figure 6.13. The basis is a rating scale, according to which every option is assessed. The rating scale is put on the x – axis, the different criteria for screening in order of importance from top to bottom on the y – axis of the diagram. Different lines are used to mark the ratings of the different options in the diagram. The resulting "profiles" for every option are a good basis for the eventual thorough discussion which will result in a final ranking of the different options.

Figure 6.13: Profile diagram for comparing different options for experimentation



6.1.6 Qualitative assessment of experimental treatments by farmers

In the early stage of an experiment the number of experimental treatments is usually relatively large and the number of farmers involved relatively small. These conditions do not facilitate a quantitative assessment of the tested options. Hence farmers assessment of the experimental treatments will be of qualitative nature at this stage.

An appropriate tool for the qualitative assessment is the dialogue on innovation with groups or panel groups. A first result can be to verify whether the list of screening criteria developed earlier is still valid at this stage or whether farmers views changed while participating in the trial. The kind of questions asked are:

- What do you think of (treatment x, y, z...)?

- What are the advantages of .....?
- Asking "why" or "can you explain this" after an answer will help to understand the reasons for farmers views.

Farmers spontaneous comments are a good indicator of what farmers consider to be the most important features of a specific experimental treatment.

Further criteria (obtained during the screening of potential options or specifically defined for this purpose) may be applied for assessment after spontaneous comments were given.

Eventually farmers views can help to reduce and adapt the choice of experimental treatments. Farmers' contributions can be stimulated with questions like:

- Do you think this treatment deserves to be repeated?
- Which treatments would you like to try again, or suggest to be dropped next season?
- Which modifications do you suggest?

Farmers' open and honest rejection of trial options requires that researchers declare their neutrality in respect to the experimental treatments and their receptivity to open and constructive criticism (see also Chapter 3 – Communication with farmers).

6.2 Analysis of information from standardized data collection

The techniques described in the following deal with the analysis of information from standardized data collection as it is applied in experiments or formal surveys.

The analysis follows largely the basic procedure outlined in Chapter 2.4.4 "Assessment of the options". The analysis consists of the preparation of data for the analysis, the actual data processing/analysis and the tabular or graphical representation.

This guide presents some standard techniques which proved to be useful for the analysis of on-farm experiments. It cannot give a comprehensive and detailed description of statistical techniques. For this reference is made to special literature.

Techniques with regard to the preparation of data are described in somewhat more detail. This important aspect of the data analysis is not covered sufficiently in the literature usually available in projects and, consequently, does often not receive enough attention. Preparation includes transforming data into a format convenient for the data processing on microcomputers.

6.2.1 Data preparation

At this stage the raw data obtained in experiments or formal surveys are prepared for the actual data analysis in a series of consecutive steps.

Check for completeness

The raw data are checked through in order to ascertain whether all the required data defined in the experimental or survey-plan were really collected. Missing numeric data can be supplemented to some extent (→ "Missing value technique"). Before this is done, it is advisable to check whether the data cannot be completed with the help of the staff responsible for recording.

Check for problem data

The following considerations refer specifically to the analysis of data from on-farm experiments.

In on-farm experiments it is more common than under station conditions that the validity of data is affected by incorrect implementation or by the destruction of experimental plants.

Incorrect implementation includes the wrong treatment application as well as the non-uniform application of non-treatment field operations. There are two basic ways of coping with such problem data (see also Table 6.4): (a) if only a few experimental units per farm are affected, the data in question are declared missing and supplemented using the missing value technique, (b) otherwise it will be necessary to disregard the whole data set for this farm. In rare cases it will be possible to save the data by redefining the experimental objectives, when all experimental units of a treatment were affected by the same implementation error.

Examples with regard to the **destruction of experimental** plants and possible remedies are given in Table 6.4. Before any adjustments of affected data are made, it must be determined whether the loss of these plants is possibly related to the treatments applied. Poor germination in certain plots of a variety trial, low plant population in the control plot of a fertilizer trial or a high level of plant damage by pests in a pest control trial

are some examples of plant destruction which is possibly related to experimental treatments.

Data adjustments are only justified if it can be safely assumed that the loss of / or damage to plants is not related to the experimental treatments applied. In this case there are two basic possibilities:

(a) if the loss or destruction of harvest products (for example by theft, premature harvest by farmers or destruction by animals) or the destruction of whole plants occured in the **yield formation phase** of the crop development, it can usually be assumed that the development of neighbouring plants will not have benefited by the destruction. The affected data are adjusted with a simple mathematical transformation in order to project the yield which would have been achieved without destruction:

$$Y_{adj} = Y_{act} \cdot \frac{P_{act} + P_{dest}}{P_{act}}$$

Y_{adj} = *adjusted yield – without destruction*
Y_{act} = *actual (unadjusted) yield*
P_{act} = *actual number of plants*
P_{dest} = *number of destructed plant*

(b) if the destruction of plants occured during the **vegetative development** of the crop it may be assumed that plants immediately adjacent to the damaged plants perform better than they would otherwise. A considerable loss of plant population is, however, very common in farmer-managed experiments and to an extent, it can be tolerated as a usual condition of on-farm trials. Data adjustments are, therefore, better based on the visual identification and subsequent counting or measuring of missing hills or vacant areas rather than on the simple comparison of actually achieved and the theoretically possible plant populations on a specific plot. There are three different ways to deal with data in the case of destruction during the vegetative development:

- No adjustments should be made, if the percentage of missing hills or vacant areas is very small (< 10 %).
- A covariance analysis is suggested for data adjustment if the percentage of missing hills or vacant areas is between 10 and 20% of the theoretical number of hills or the plot size.
- If more than 20% of the expected hills or the plot area is vacant, the data for the respective plots are declared missing and the missing value technique is applied.

Check for data consistency

In this step it is checked whether all data of a given data set are consistent in themselves.

With regard to **survey data** this means ascertaining that the answers given to different questions within one interview are not contradictory. Before a decision is made to disregard an inconsistent questionnaire, an attempt should first be made to rectify contradictory answers in cooperation with the responsible interviewer.

It often happens with data from **on-farm experiments** that some data appear to be too low or too high in comparison to other data of the same data set.

There is a considerable debate in the liteature as to whether it is justified to adjust data that appear to be inconsistent. Some inconsistency is certainly tolerable in on-farm trials if it is expected that a successful innovation shows a relatively high advantage as compared to the present technology.

Inconsistencies can have a variety of different causes, like:

- incorrect measurements or data transcriptions;
- undiscovered errors in trial implementation;
- the heterogeneous farm environment;
- a behaviour of experimental treatments which does not accord with the researchers expectations.

It is not acceptable to manipulate or disregard data just because they do not conform with the researchers preconceived ideas.

If data are checked early enough it is often possible to rectify incorrect measurements or data transcriptions by going back to the field notes of the recording staff or by re-measuring harvest samples.

Table 6.4: How to deal with problem data

Problem	Remedies
Incorrect implementation	(a) declare missing, if 1 (max.2) plots per farmer affected; missing value techn. (b) redefine objective if all plots of a treatment in a trail are affected alike (c) disregard data set if (a) and (b) not possible
Destruction of plants • poor germination • physical damage • damage by pests, diseases or animals • parts of harvest prematurely harvested or stolen • etc.	**Adjustment only if problem not related to poor germination treatment !** (a) only harvest produce, or plants affected during yield formation = simple projection of theoretical, based on actual data x expected over destructed no. of plants (b) plants affected during vegetative growth (i) no adjustment for low degree of destruction (< 10 % of hills missing or area vacant) (ii) analysis of covariance for moderate degree of destruction (10 – 20% of hills missing or area vacant) (iii) failed plots are declared missing for high degree of destruction
Unforeseen heterogeneity of farm environment • soil differences • drainage differences • etc.	(a) declare data missing if 1 (max. 2) plots per farmer affected: missing value tech. (b) analysis of covariance, if characters were measured before treatm. application which are closely related to the respective variable (like plant height to crop yield) (c) disregard data set if (a) and (b) not possible

Data adjustments are only justified if the inconsistency observed can be clearly related to heterogeneity of the farm environment (like unforeseen differences with regard to soil fertility or drainage conditions). There are three possible ways to deal with such data:

- The data in question are declared missing and supplemented using the missing value technique, or
- a covariance analysis is used if characters which are closely related to the respective variable (like plant height to crop yield) were measured **before or at** treatment application;
- the questionable data set is disregarded if both adjustment techniques are not applicable.

Missing value calculation

Where necessary missing values are calculated using the folowing formula:

$$\textit{Missing value} = \frac{t \cdot T + r \cdot R - S}{(t-1) \cdot (r-1)}$$

t = *number of treatments*
T = *sum of the results of the treatment with the missing value*
r = *number of replicates*
R = *sum of the reults of the block with the missing value*
S = *sum of the results of all plots in the trial*

Most of the relevant statistical computer programme facilitate the computation of missing values (for example the modules ANOVA-2 and MISVALEST of MSTAT) or delete observations with missing values from the analysis (like the GLM-ANOVA in Solo).

Preparing the data matrix

Almost all statistical analysis procedures are working on the basis of a data matrix as it is shown in Table 6.6. The lines contain the results for the different cases or "units of investigation" (i.e. one line contains all the results for one plot in the case of data from on-farm experiments or all information from one interview in the case of a survey), the columns the different variables.

The major steps in the preparation of the data matrix are:

(a) the elaboration of a codeplan;

(b) coding of information;

(c) entering the information into the matrix.

Codeplan

For the computer analysis all information needs to be available in an appropriate form. A data transformation is therefore especially necessary for all non-metric data.

Most results from **on-farm experiments** will already be available in metric form and do not require coding. Coding is, however, required for the designation of the experimental plots.

Survey data are often not available in a form appropriate for a computer analysis. The multitude of possible answers to open question of the questionnaire will first of all have to be assigned to a few answer categories, if possible answers were not categorized already during the questionnaire design. Subsequently a code is given to every answer category.

The sample codeplan in Table 6.5 shows
- which variable will be accomodated in which column of the data matrix, and
- which figures (="codes") will be assigned to which variable descriptions.

In this example every plot is identified by 6 variables (season, site, farmer, plot number, variety and time of planting) accommodated in the first six columns of the data matrix (see Table 6.6). Figures assigned to every variable description are shown under "designation". For example with regard to "seasons" a "1" will be used in the data matrix for 1992 and a "2" for 1993; for site a "1" is used for x-village, a "2" for y-village. Yield data contained in columns 7 – 15 of the data matrix do not require coding. Proper preparation and storage of the codeplan helps to ensure that the data entered into the data matrix are well understood by everybody involved in the data processing.

Table 6.5: Codeplan for on-farm trial "Cowpea varieties for interplanting with cotton" (adapted from DAO, DLASO and GASP trial programme, Lamu, Kenya)

Column	Variable	Designation	
1	Season	1 = 1992 2 = 1993	
2	Site	1 = x-village 2 = y-village	
3	Farmer	**x-village**	**y-village**
		1 = (name)	(name)
		2 = (name)	(name)
		3 = (name)	(name)
		4 = (name)	(name)
4	Plot number	1 – 6	
5	Copea variety	1 = K 80 2 = M 66 3 = farmers	
6	Time of cowpea interplanting	1 = 3 weeks after cotton 2 = farmers time	
7	Cowpea yield	kg/ha	
8	Cotton yield	kg/ha	
9	Cotton grade 1	%	
10	cowpea yield	kg/plot	
11	cowpea moisture	%	
12	cowpea estim. shelling	%	
13	cowpea net plot size	m^2	
14	Cotton net plot size	m^2	
15	Cotton yield	kg/plot	
16	Cotton yield grade 1	kg/plot	

Table 6.6 contains part of the data matrix used for the on-farm experiment "Cowpea varieties for interplanting with cotton". The 16 columns of the data matrix contain the variables described in the codeplan. The data matrix contains only metric data. The sample matrix was created on a LOTUS spreadsheet. It was transformed into ASCII format and imported into MSTAT for the actual data analysis.

Note: raw data with yield parameters on "**per plot**" basis were entered in column 10 – 16 of the matrix. The spreadsheet programme was used to perform the conversion into yield data on "**per hectare**" basis on which the actual statistical analysis is done. Similar transformations can be done with almost all statistical programmes. The raw data can be entered right from the field record form, if the order of variables in the record form corresponds with that of the data matrix.

Table 6.6: Data matrix for on-farm trial "Cowpea varieties for interplanting with cotton" (adapted from DAO, DLASO and GASP trial programme, Lamu, Kenya)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	1	1	1	1	132	1579	89	1.6	15.5	55	64.8	42.1	6.65	5.94
1	1	1	2	2	1	482	843	85	5.8	14.9	55	64.8	42.1	3.55	3.03
1	1	1	3	3	2	148	772	95	1.85	17.8	55	64.8	42.1	3.25	3.09
1	1	1	4	3	1	103	1223	95	1.25	15.3	55	64.8	42.1	5.15	4.89
1	1	1	5	2	2	140	985	93	1.7	15.7	55	64.8	42.1	4.15	3.88
1	1	1	6	1	2	65	1080	94	0.8	16.9	55	64.8	42.1	4.55	4.26
1	1	2	1	1	1	325	724	100	3.9	14.7	55	64.8	42.1	3.05	3.05
1	1	2	2	2	1	1007	1199	100	12.2	15.4	55	64.8	42.1	5.05	5.05
1	1	2	3	3	2	183	760	100	2.2	14.7	55	64.8	42.1	3.2	3.2
									⋮						
1	2	3	4	3	1	0	1140	100	0	17	100	64.8	42.1	4.8	4.8
1	2	3	5	2	2	212	3822	100	1.42	15.7	100	64.8	42.1	16.1	16.1
1	2	3	6	1	2	366	3122	100	2.42	14.7	100	64.8	42.1	13.1	13.1
1	2	4	1	1	1	315	1062	100	3.8	15.1	55	64.8	40.5	4.3	4.3
1	2	4	2	2	1	166	1430	100	2	14.8	55	64.8	48.6	6.95	6.95
1	2	4	3	3	2	0	1934	100	0	15	55	64.8	48.6	9.4	9.4
1	2	4	4	3	1	488	1157	100	5.9	15.2	55	64.8	30.2	3.5	3.5
1	2	4	5	2	2	144	0	100	0.95	14.6	100	64.8	48.6	8.75	8.75
1	2	4	6	1	2	129	1667	100	0.85	14.3	100	64.8	48.6	8.1	8.1

Coding

The codes are
- either entered directly in the proper record form or questionnaire, which means that provision was already made for this when the questionnaire was designed, or
- first transcribed by hand into a codeform equivalent to the data matrix subsequently used.

With some computer programmes (like dbase) it is possible to enter non-metric information and have the computer transform the data. Entering coded information, however, is usually less time consuming.

6.2.2 Data analysis

Three components of data analysis are explained in the following section:
- the statistical analysis of agronomic data;
- the economic analysis and
- and the analysis of farmer' assessment.

6.2.2.1 Statistical analysis of experimental data

The statistical analysis of agronomic data is the basis for the **assessment of the feasibility of a potential innovation under given natural environment(s)**. This includes aspects such as:
- the production of a trial innovation as compared to the present technology;
- the adaptability of a trial innovation to different environmental conditions;
- the expected production risks of the potential innovation.

The statistical analysis of experimental data is furthermore the basis for the subsequent economic assessment.

Analysis of variance (ANOVA)

The analysis of variance will usually be the first step of the statistical analysis. It determines to what extent factors like experimental treatments and site specific conditions contributed to the observed differences between experimental treatments.

The statistical significance of the observed treatment differences is determined with the **"F-Test"**. The F-test compares the computed F-value (= Treatment MS over Error MS) with the tabular F-value. If the computed F-value is higher than the table value at the 1% level of significance (= probability or "p"-level) the treatment differences are said to be highly significant. Such results can be indicated by placing two asterisks on the computed F-values in the ANOVA – table. In view of the normally high variation of results, a p-level of 5% (i.e. one asterisk on the computed F-value) will be acceptable for on-farm trials.

Most statistical computer programmes calculate the p-level automatically and show it in the ANOVA-table, so that the comparison of computed and tabular F-values will usually not be necessary anymore.

The **F-test** decides, however, only **whether there were statistically significant differences** between the treatments of an experiment. A subsequent **comparison between treatment** means will have to show **which treatments were significantly different** if a trial was comprising of more than two treatments.

The appropriate analytical procedure for the analysis of variance is already determined during the design of experiments (see Chapter 5.2).

Calculating the **interaction between farms and treatments** is not possible **without replication of treatments on the same farm**. If there was no replication within the same farm but treatments appeared to perform differently on different farms, suitable farm-specific factors (like quality of weeding, time of planting or a management factor combining the quality of various key operations) should be identified and subsequently included in the analysis of variance as an additional variable.

Replication of treatments within the same farm allows the computation of treatment x farm interaction. This reveals **whether** there is an interaction. In case of the interaction term being significant, it will again be necessary to determine which farm-specific factors contributed to it. The conclusion depends on the objective:

- if the aim is to develop an innovations with a **wide adaptability**, then technologies are to be identified whose average effects over farms are high and stable;
- if the aim is to develop **specific technologies for specific types of farms**, then conditions are to be defined under which a specific technology will be applicable.

An important trial objective is often to examine which treatment is adapted to which kind of environment. The analysis of variance over different sites or season shows **whether** treatment effects change under different environmental conditions. This analysis requires, however, that the same treatments and the same experimental design are applied over all sites or seasons.

The analysis over different **sites or agroecological zones** with sites or zones as an experimental variable allows a computation of the interaction between treatments and sites (or zones). Specific environmental conditions (like soil parameters) are preferably defined before experiments are carried out and trial farmers selected accordingly (see Chapter 5.2.2). It is usually more difficult to group farmers into appropriate environmental categories after trial implementation. A non-significant interaction – F means a high degree of treatment adaptability to different environments. A significant interaction term calls for further analysis in order to determine which treatments are best adapted to which environmental conditions.

The variability of climatic conditions over years is relatively unpredictable. The **combined analysis over years at a given site** or a given agroecological zone therefore aims at the identification of treatments whose average effect over years is high and stable at this particular site or zone. If the treatment x year interaction is relatively low it can be expected that the ranking of treatments is stable over years and the interaction can be ignored. If the interaction is significant, it is likely that the ranking of treatments changes over years and it would be necessary to examine the nature of the interaction.

Comparing treatment means

When the analysis of variance yields significant F-values, the comparison of treatment means is a follow-up procedure to analyse **which treatment means differ from each other**. **Pair comparisons** (i.e. comparing two treatment means at a time) are the most commonly used comparisons in agricultural research. There are two major groups of pair comparisons:

- **planned comparisons** in which specific pairs of treatments to be compared are identified already before experimentation, and
- **unplanned comparisons** in which every possible pair of treatment means can be compared to identify significant differences, without prior planning.

The most commonly used **planned comparison** is the least significant difference (LSD) test, because of its simplicity. This test can, however, easily produce misleading results if it is wrongly applied: if it is used to compare every possible pair of means, it is likely to show significant differences even if the F-tets did not yield significant treatment differences. The likelyhood that the LSD-test shows significant treatment differences increases with an increasing number of treatments. To avoid misleading results it is recommended to apply the LSD test only if the F-test for treatment differences was significant and if the number treatments is smaller than 6 (Gomez and Gomez 1983). Most appropriately it is used to compare the control treatment with the other treatments of a trial.

Safer in their application are **unplanned comparison** which allow the comparison of every posible pair of treatment means without prior planning for it. The relevant statistical computer programmes usually contain a number of mean comparison tests (MSTAT, for example, provides under "Range Tests": Duncan's Multiple Range Test, Tukey's Test and Student Newman-Keul's Test). Some care is, however, required if the procedures are applied on **factorial experiments** (i.e. trials involving more than 1 experimental factor, see Chapter 5.2.4): If the F-test shows non-significant interaction effects, only the main effects of the different factors should be compared (e.g. the means of the levels of factor A over all levels of factor B). The mean separation procedure is applied on the factor level combinations only if the F-test showed significant interaction effects (see Annex 6.1).

Estimating stability

If the interaction between treatments and farms, sites or years proves to be significant in the analysis of variance, the stability of the different treatments will need further analysis and comparison.

A simple way to estimate and compare **stability of treatment means over different farms, environments and years** is the computation of **frequency distributions**. The Box-and-Whisker-Plot shown in Figure 6.14 is a tool to **identify treatments which are stable over a range of conditions.** It is calculated by most of the suitable computer programmes and can be used to show median, range and quartiles of treatment values across farms. The treatment mean can be included in addition to the median. A narrower range of treatment values means higher stability or better adaptability to different conditions. If two treatments show similar mean values, the one with the narrower range is preferable. This technique is appropriate in particular for the verification stage of an experiment with a relatively large number of participating farmers.

A tool which helps to determine **which treatments are best adapted to which environments** is shown in Figure 6.15. The yields of the treatments tested are plotted **against farmers, villages or agroecological zones**. This kind of graph allows the comparison of adaptability of treatments over different environments. It shows which treatments were "stable" over all farmers, villages or zones, and at which farms, villages or zones a treatment performed well or poorly. Thus it helps to identify the specific conditions to which a particular treatment is well adapted and those for which it is less suited. This technique provides good results with relatively few farmers, villages or zones to be analyzed. (Similar is the modified stability analysis of Hildebrand and Poey (1985) in which mean yields at each location are used as "environmental index" against which individual treatment yields are plotted.)

Figure 6.14: Box-Whisker-Plot

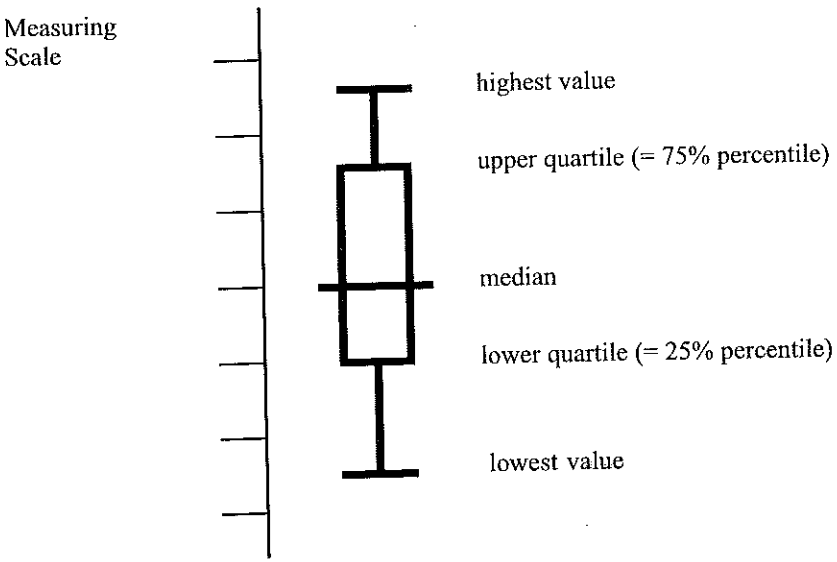
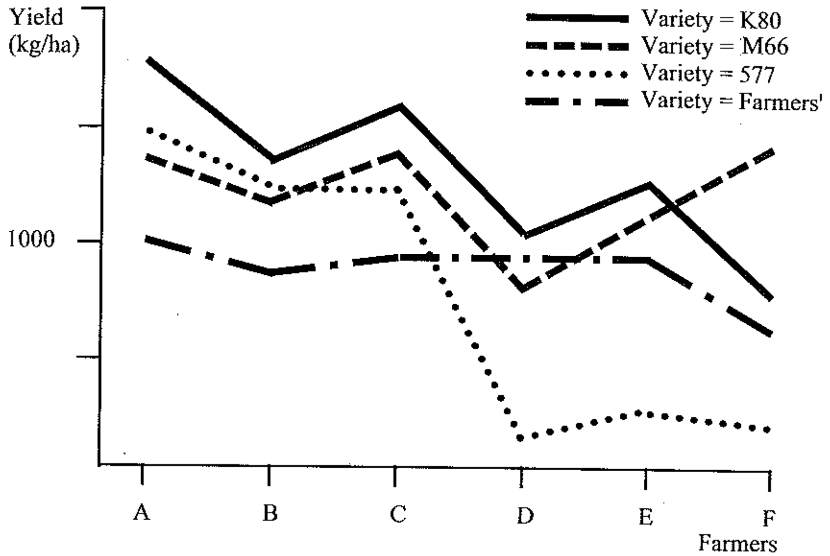


Figure 6.15: Graphical assessment of the adaptability of different cowpea varieties to different farm conditions



Estimating risks chances of success

A key criterion for the quality of a potential innovation is the risk of failure or, seen positively, the chance of success to be expected.

The "risk" is defined as the probability that a potential innovation fails; conversely, the "chance of success" is the probability that a potential innovation will succeed. An appropriate basis of comparison is the farmers' present practice, which is usually the control treatment. "Failure" therefore means that the potential innovation did not achieve the yield level obtained through farmers' present practice on a particular farm.

A better basis for comparison would be the result of farmers present practice **plus** a defined margin (e.g. 30%), because it would be expected that an innovation is not only superior, but clearly superior to present cultivation practice.

The simple calculation is as follows:

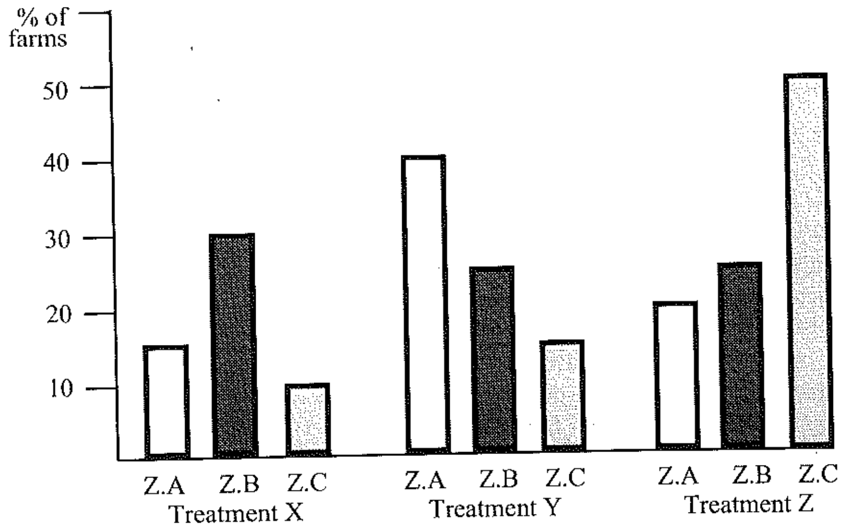
$$Risk\ of\ failure = \frac{No.\ of\ farms\ at\ which\ innovation\ failed}{Total\ no.\ of\ farms\ involved\ in\ the\ trial} \cdot 100\%$$

The results are represented in tabular form (see Table 6.7) or as bar chart (Figure 6.16). The consideration of an additional variable (like agroecological zones) is possible in both cases.

Table 6.7: Table for "risk of failure" in different agroecol. zones (% of farms at which exper. treatments did not obtain a yield level 30% higher than control)

	Treatment X	Treatment Y	Treatment Z
Zone A	15	42	20
Zone B	31	28	24
Zone C	12	13	51

Figure 6.16: Bar chart for "risk of failure" in different agroecol. zones (% of farms at which exper. treatment did not obtain a yield level 30% higher than control)



Analysis of intercropping trials

Trials with two or more crops grown simultaneously require a different approach than trials with just a single crop. The analysis of such trials differs from that commonly used for station trials insofar as indicators such as the "Land Equivalent Ratio" (LER) cannot be calculated because there are usually no special plots for single crops. (In an on-farm experiment all treatments tested should be real options to the farmer. Hence, it is not recommended that a treatment be implemented just for calculatory purposes).

In the absence of single crop plots, total yields of different crop mixtures can be compared by converting grain or tuber yields to calories or protein. This conversion however has a disadvantage similar to that of the LER: the calculation of the total yield (in calories) or of an (artificial) ratio may not reflect farmers' real desires.

An aim often observed is to produce as much as possible of the main or staple crop with a supplement provided by the secondary crop. In this case the effect of the innovation on the yield of the main crop would have to be valued higher than that on the intercrop yield.

Particularly in intercropping trials aspects other than yield are often highly important. Changes in intercropping arrangements can, for example, have significant effects on resource allocation (like additional labour requirements in critical periods or additional chemicals). As such important criteria tend to be overlooked by researchers, the dialogue on innovation plays a particular outstanding role for the assessment of options in this more complex type of experiments.

6.2.2.2 Economic analysis of experimental data

A potential innovation usually involves additional inputs in terms of seed, fertilizer, labour etc. A tested technology may gain a higher yield, but the farmer would not benefit if the additional expenses exceed the value of the additional production. A potential innovation may be more profitable per area of land, but not attractive to the farmer if it involves more labour and thus less profit per unit of labour than the present practice.

Economic considerations are therefore of vital importance in interpreting agronomic trials and making recommendations wherever the tested innovations require the use of additional resources.

A word of caution: the superiority of a potential innovation in monetary terms does not guarantee that it will eventually be adopted by farmers. Economic indicators are the more important the more a specific target group and the farm activity involved is embedded in the market economy. Economic indicators will be of little significance for highly subsistence-oriented farmers or crops exclusively grown for home consumption. It is, therefore, essential to determine and rank indicators for the analysis in the dialogue on innovation (see Chapter 4.2.2) before a decision is made about the mode of the economic analysis and its value in comparison to the agronomic analysis and the farmers' assessment.

Selection of evaluation criteria

The economic analysis evaluates returns on the **production factors of land, capital and labour**. Not all these factors need to be considered routinely for every experiment. The choice of appropriate criteria for the economic analysis is determined by:

(1) the role of a production factor in the specific experiment;
(2) the availability of a production factor in the farm economy of the target group.

(1) Returns are calculated only for those production factors which are actually affected by the trial innovations. A production factor not affected by the innovation tested in the experiment does not need to be considered in the analysis. The production factor "land" is involved in all experiments dealing with crop production. **Returns on land** (i.e. gross margins) are therefore calculated for all these experiments. The calculation of **returns on capital** is useful when a potential innovation requires a substantial amount of additional capital. The **returns on labour** should be calculated, whenever a potential innovation affects the labour allocation. Some suitable economic indicators are presented in Table 6.8. . Table 6.10 shows some examples of production factors affected in different types of experiments and the choice of suitable indicators for economic analysis.

(2) The relative importance of criteria chosen for the economic analysis is determined by the **relative availability** (or scarcity) **of a production factor** in the farm economy. The returns on a factor more scarce in the farm economy should be valued higher in the economic analysis than the returns on a factor available in relative abundance.

The concept of "partial budgeting"

To simplify the budgeting procedures, all considerations of costs and benefits in this context disregard the element of "fixed" costs. This is based on the assumption that potential innovations tested in on-farm experiments will only cause changes in the "variable costs". Budgeting procedures need to be adjusted wherever this assumption does not hold true.

Table 6.8: Choosing economic indicators on the basis of production factors affected by the potential innovation

Production factor affected	Suitable economic indicators
Capital only	– gross margin + returns to variable costs or + marginal rate of return (for **systematically increasing levels** of an experimental factor)
Labour only	– yield / labour ratio
Capital + labour	– gross margin + returns to var. costs or marg. rate of return + (monetary) returns on labour

Table 6.9: Some economic terms

Gross margin / ha = gross retuns/ha – variable costs/ha
The gross margin is the monetary value of a crop per unit of area after deduction of the variable input costs required to produce this crop.

Returns to variable costs = gross returns / variable costs
The returns to variable costs relate the gross returns of a farm activity to its variable cost.

Marginal rate of return = $\frac{\textit{Incremental gross margin between 2 treatments}}{\textit{Incremental costs between these 2 treatments}} \cdot 100\%$

The marginal rate of return indicates which additional gross margin is obtained per unit of additional variable costs between two treatments. It replaces the returns to var. costs in the analysis of experiments with systematically increasing levels of an experimental factor (e.g. fertilizer levels).

Yield/labour ratio = yield of a crop / units of labour applied on this crop
This ratio shows how much yield is obtained in relation to one unit of labour applied. It is used for experiments in which only the factor labour but not capital is affected by a potential innovation.

(Monetary) returns on labour = gross margin / units of labour used to obtain the gross margin
This indicator shows the magnitude of gross margins obtained in relation to one unit of labour applied. It replaces the yield/labour ratio where labour **and** capital are affected by an innovation.

Risks and stability

Some simple methods to compute the stability of treatments over different environments and the risks connected with the application of the tested treatments were shown already in the agronomic analysis. The same methods introduced there are applicable also for the economic analysis of experimental data.

It will not be necessary to consider stability and risks in both the agronomic and the economic analyses. In the more common case that an innovation requires additional resources, the comparison of risks and stability of the different options tested will be more appropriate in the economic analysis.

Table 6.10: Some examples of production factors affected by different trial types and the choice of economic indicators

Type of trial	Production factor affected	Choice of indicator for economic analysis
Variety trial	Capital (costs of new variety higher than the local standard, but no systematically increasing levels of capital)	– gross margin + returns to var. costs
Fertilizer levels	Capital (costs of fertilizer systematically increasing)	– gross margin + marginal rate of return
Methods of fertilizer application (e.g. once or split)	Labour (more for split application)	– yield/labour ratio
Application of organic manure	Labour (for collecting, processing and application)	– yield/labour ratio
Alley cropping*	Capital (for seed or seedlings)	– gross margin + benefit/cost ratio
	Labour (to establish and maintain alleys)	+ (monetary) return on labour

* Alley cropping trials and any trial involving perennial crops would, strictly speaking, require a cash flow analysis. For this reference is made to special farm economics literature (e.g. Stroebel, 1987)

6.2.2.3 Analysis of farmers' assessment

The superiority of an innovation in both agronomic and economic terms does not guarantee that it will be eventually adopted by farmers. A complementary farmer assessment should ensure that those criteria important to farmers are not overlooked in the analysis.

The following describes some methods of farmer assessment which are especially suited for the quantitative analysis of relatively large and representative groups of farmers and few treatments (not more than 4 or 5). The techniques are applicable at an advanced stage of a trial, with only a limited choice of options remaining. Techniques of a more qualitative nature are applied for farmer assessments involving larger numbers of options (see Chapter 6.1.6). Two of the methods described in the following (rating and matrix ranking) require the prior identification of suitable assessment criteria (see Chapter 6.1.5).

Rating

The procedure applied is similar to the one used for the identification of assessment criteria (see 6.1.5). The 5 – 10 criteria considered most important by farmers are set out on a rating scale (Figure 6.17) which is used to gain a farmer-by-farmer rating of the quality of the experimental treatments.

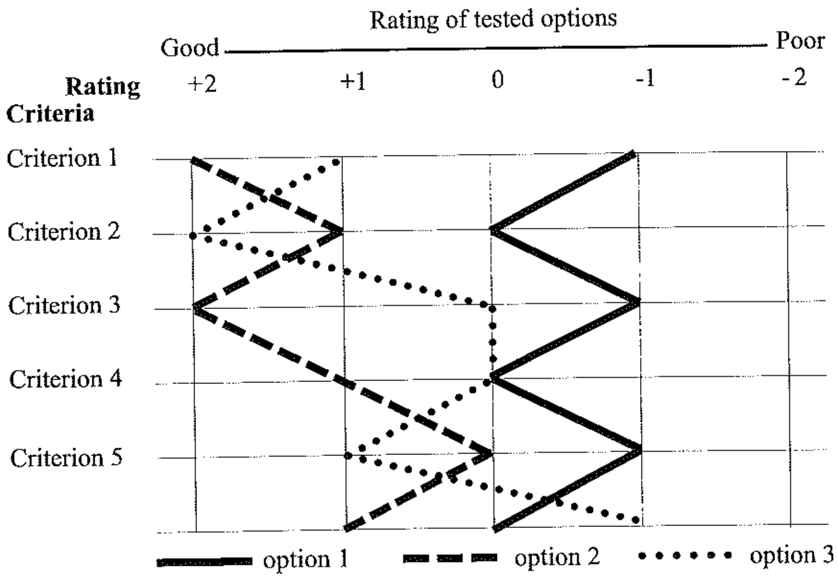
A mean rating is calculated treatment by treatment for every criterion either for all farmers or for suitable subgroups (i.e. all farmers of a village, a zone or defined "target groups").

The mean ratings for the tested options are tabulated or graphically compared in a profile diagram as shown in Figure 6.18. The rating scale is laid on the x – axis of the diagram, the assessment criteria in order of their importance on the y – axis. Different symbols are used to mark the ratings of the different options to be compared. The "profiles" for every option are a good basis for a discussion on the overall rating of the different tested options. This is best done together with the farmers involved in the experiment.

Figure 6.17: Rating scale for farmers' assessment of cowpea varieties

Rating criteria	Varieties	Assessment				
		very good		fairly good	poor	
		(2)	(1)	(0)	(-1)	(-2)
Compatibility with cotton	Var. X	❑	❑	❑	❑	❑
	Var. Y	❑	❑	❑	❑	❑
	Var. Z	❑	❑	❑	❑	❑
Drought resistance	Var. X	❑	❑	❑	❑	❑
	Var. Y	❑	❑	❑	❑	❑
	Var. Z	❑	❑	❑	❑	❑
Taste + flavour	Var. X	❑	❑	❑	❑	❑
	Var. Y	❑	❑	❑	❑	❑
	Var. Z	❑	❑	❑	❑	❑
• •						

Figure 6.18: Profile diagram for comparing farmers' ratings of different options tested in an on-farm experiment



Matrix ranking

Matrix ranking involves asking farmers to rank the experimental treatments with respect to defined assessment criteria. As for the rating, assessment criteria are identified by farmers in advance. The most important 5 – 10 criteria are chosen for the matrix ranking. A rank is given to every treatment with respect to every criterion applied.

Figure 6.19: Example of a matrix ranking of different cowpea varieties in a farmer evaluation

Cowpea Variety	Criteria								
	Over-all rank-ing	Yield poten-tial	Early ma-turity	Pest and disease resist-ance	Com-pati-bility with cotton	Grain colour	Grain size	Time for cook-ing	Taste and flavour
K 80	1	2	1	3	2	1	3	1	1
M 66	2	1	3	1	1	3	3	3	3
K o95	3	4	1	3	4	1	1	1	1
Local	4	3	4	2	3	4	1	4	4

Pairwise comparison

By comparing in pairs each option tested can be judged as better or worse than another. A reason for this judgement is given. In a complete comparison of pairs with a maximum of 3 to 4 treatments to be compared, all treatments are compared with each other: A with B, A with C, A with D; B with C and B with D; C with D. This kind of comparison helps to identify the most important advantages and the most critical disadvantages of all options tested. It can eventually result, again, in a ranking of the different options. This method is useful also for the identification of suitable options for experimentation before trials are carried out. An example of comparison by pairs is given in Figure 6.20.

Figure 6.20: Example of a complete comparison by pairs of 4 treatments (adapted from Ashby, 1990)

Pair compared	Reasons for assessment	Score			
		1	2	3	4
1 : 2	Coffee is less risky than vegetables.	+	–		
1 : 3	Coffee is more profitable than rice.	+		–	
1 : 4	Maize is difficult to market, price is low, only useful for home consumption.	+			–
2 : 3	Vegetables more risky than rice but more profitable when prices are good, although you can loose your shirt.		+	–	
2 : 4	Maize only for consumption		+		–
3 : 4	Rice not very profitable but necessary to grow it for daily consumption, and what remains goes for sale; maize not worth selling, is only eaten occasionally, not everyday like rice			+	–
Total Score And Rank Order	Positive (+)	3	2	1	0
	Negative (–)	0	–1	–2	–3

Note: – Options: 1 = coffee, 2 = vegetables, 3 = rice, 4 = maize
– The positive (+) or negative (-) scores are entered into the score matrix as follows: options 1 vs 2: 1 is scored a (+), therefore 2 is scored a (-); options 1 vs 3: 1 is scored a (+), therefore 3 scored a (-), etc. When the scoring is completed, the number of (+) signs can be summed to each option in the scoring matrix. This gives a rank order of the options. (The final assessment should however not be based on the mechanical addition of scores but on a thorough discussion of the advantages and disadvantages mentioned.)

Monitoring spontaneous adoption

The verbal assessment of trial options by farmers may not be the ultimate indicator for the quality of a potential innovation. However it is available soon after a trial season and therefore helps to adapt experimental designs. But a positive verbal assessment does not necessarily mean that a proposed innovation will eventually be adopted by farmers. The fact that an interview does not always reveal the real views of the farmer and the reasons for this were already highlighted in chapter 4.1.2. In addition, the experimental treatment which may appeal to farmers on the first glance may eventually not be feasible under real-life conditions (consider, for example, the nice car passing by on the road, which is really attractive – but nevertheless you can't afford to buy it).

A better proof of the quality of a potential innovation is the spontaneous adoption by farmers who were exposed to it. A means of investigating spontaneous adoption is a simple survey implemented in the season after the experiment was carried out.

It should explore

(a) quantitatively:
 - how many (or what percentage) of farmers exposed to the experiment adopted which of the trial options;

(b) qualitatively:
 - what are the reasons for adoption or non-adoption of trial options;
 - what kind of modifications were made to the original experimental treatments;

(c) whether adoption or non-adoption depends on specific target group characteristics of farmers.

Combining interview **and** observation in the field helps ensure that the information obtained reflects the true situation.

A quantitative assessment gives some indication of the extent to which a potential innovation would be adopted if it were promoted by the extension service. A high rate of spontaneous adoption suggests that a technology can be confidently promoted by the extension service. A high degree of rejection means that a trial innovation is not ready for extension recommendation.

In the latter case knowing the reasons for non – adoption and observing what modifications are made by farmers helps the researchers to improve the experimental options and to adapt the trial design.

Analysing farmers' assessment for statistical significant differences between treatments

Analysis of variance, T-test and mean comparison procedures as they were discussed in Chapter 6.2.2.1 are applicable only on measured (metric) figures, but not on ordinal numbers from farmers' ranking or rating of treatments. There are, however, very simple "nonparametric" tests available which can be used to analyse whether there are **significant differences between treatments with regard to their assessment by farmers.**

A very useful test is **Friedman 's test**, which is unfortunately not offered by every statistical computer programme, but very easily calculated by hand (see Annex 6.1). It is the nonparametric analog to the two-way randomized complete block (factorial) analysis of variance F-test. It is used to test differences among treatment means when the same set of treatments was assessed by all farmers involved in the assessment. It allows the comparison of more than 2 treatment means for a single variable (such as the overall assessment of treatments or any other defined assessment criterion) at a time. Scored (rated) as well as ranked data can be used.

The **Mann-Whitney-Test** can be applied on data from rating or ranking if there are only two treatments to be compared.

The **Wilcoxon Matched Pairs Test** is used to test differences between two **paired groups** of data, as they appear for example in the "pairwise comparison".

A matter of interest is sometimes to determine whether there is a **relationship between specific target group characteristics of farmers and their preference for a particular treatment**. This can be checked with an analysis of frequencies in a two way table (see Annex 6.1).

Cochran's Q-test is a modification of Friedmans's test which is applied when data exist only in two categories (for example "above average" and "below average", or "adopted" and "not-adopted"). It allows therefore to analyse data from adoption surveys on **differences between treatments with regard to adoption by farmers** (see Annex 6.1).

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Annex

Annex 6.1: Examples

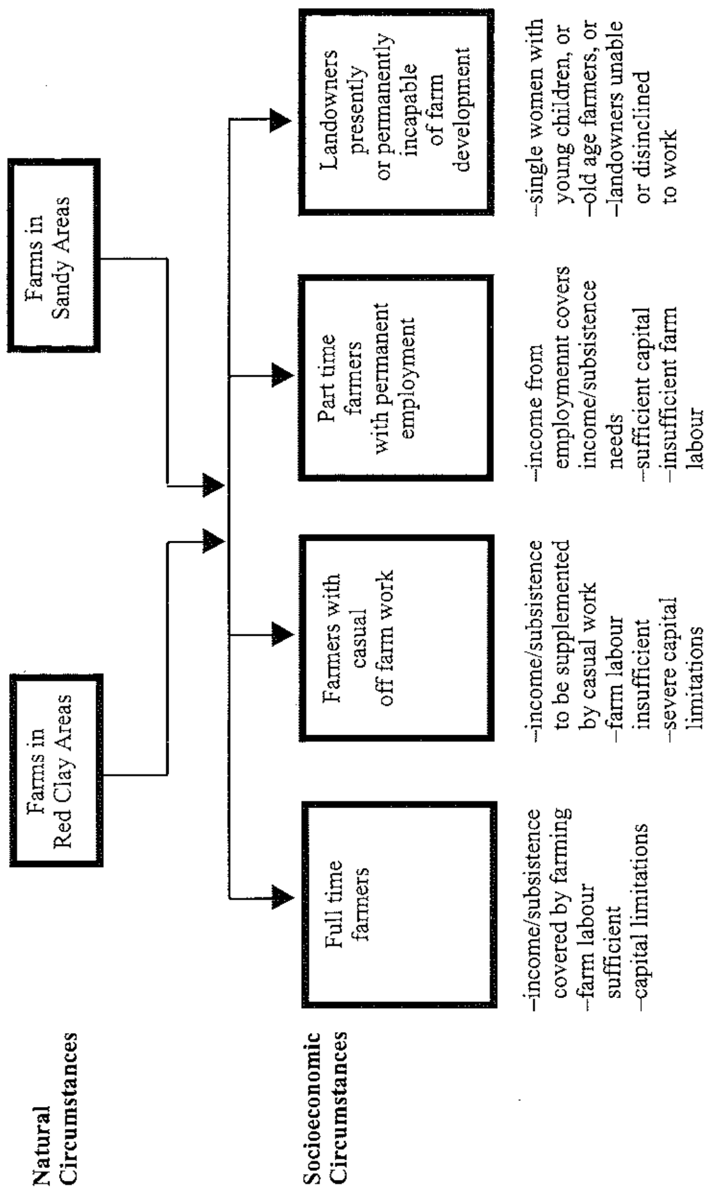
I Target grouping

Example 6.1 shows the **principal target group analysis** of a project. This kind of analysis tries to give an answer to the question "**which group of people is the project going to support?**". In this example the "part-time farmers with permanent employment" will not need the support of the project whereas the "landowners presently or permanently incapable of farm development" can hardly benefit from economically oriented development measures. The projects' target group should therefore be the "full time farmers" and the "farmers with casual off-farm work". This target group definition, of course, determines the groups of farmers to participate in research efforts.

This target grouping is not always specific enough with regard to the analysis of problems and potentials. It is sometimes only part of a target group which suffers from a specific problem or has a particular development potential. The analysis of problems and potentials calls therefore for a target group analysis specific to the identified problems and potentials. This warrants that

- the significance of a problem or potential is appropriately assessed and
- that relevant farmers are involved in the subsequent steps of the work.

Example 6.1: Project Specific Target Grouping (adapted from Neunfinger, Schmale and Werner, 1987)



A target group analysis specific to a problem or potential is shown in Example 6.2 The table shows the definition of problems and potentials identified (see Chapter 6.1.4) in the 2nd column, defines the groups of farmers affected by a problem or having a potential in the 3rd column and estimates the rate of farmers in these particular groups as compared to the total project target groups in column 4.

For most of the problems in the example, the group of farmers affected is simply defined by whether they grow a particular crop or not. Only those farmers who grow the crop in question and suffer from the identified problem should be involved in the identification and testing of possible solutions.

For some of the problems and potentials it is, however, a particular group of farmers that is involved: "Storage losses" (no.2), for example, is a problem which affects farmers in particular areas of the project (i.e. areas which are free of baboons and wild pigs and therefore allow the cultivation of maize on a larger scale). Working with farmers outside these areas would not be meaningful. Probably only farmers with access to water for supplementary irrigation would have the potential for vegetable production (no. 8), because sufficient labour would be available only from the second half of the rainy season into the dry season, i.e. at a period with an unreliable rainfall.

Example 6.2: Definition of problem or potential specific target groups (recommendation domains)

	Problem/potential	Group of farmers affected	Estimated % of project target groups
1	Interplanted cowpeas entangle cotton	Cotton/cowpea growers, in all project target groups	75
2	Storage losses of maize due to weevils	Maize growers with storable surplus, i.e. farmers in central project area (= area free of wildlife)	20
3	N & P deficiency of cotton and maize at sandy soil	Farmers in areas with sandy soil, in all project target groups	60
4	delayed 1st weeding affects annual crops	Farmers with labour shortage early in season; i.e. dominantly part time farmers with casual employment	50
5	Cashewnuts die for unidentified reason	Cashew growers, in all project target groups	95
6	Insect pests destruct cotton flowers and bolls	Cotton growers, in all project target groups	95
7	Citrus suffers from scab	Citrus growers, dominantly part time farmers with permanent employment	0
8	High demand for onion, green pepper, carrots,etc	Farmers with access to water for supplementary irrigation	25

Sometimes the problem specific target group analysis serves to exclude problems or potentials from further attention. In the example "citrus scab" (no.7), for instance, is a problem chiefly affecting "part-time farmers with permanent employment". This is a group of farmers outside of the projects main target group.

II Analysis of problems and potentials

(The following examples are based on discussions with farmers and field level extension workers at Lamu District / Kenya, 1991).

Example 6.3: Brainstorming
The brainstorming session results in an initial list of "problems and potentials".

Example 6.3: List of problems and potentials **(initial list)**

1 Interplanted cowpeas entangle cotton	**2** Storage of maize	**3** No fertilizer is applied	**4** Nutrient deficiency of cotton and maize on sandy soil
5 Delayed 1st weeding affects yields of annual crops	**6** Cashewnuts die for unidentified reason	**7** Insect pests destroy cotton flowers and bolls	**8** Input supply structure is weak
9 All crop residues are burnt	**10** Citrus suffers from scab	**11** High demand for vegetables = chance for diversification	**12** Cotton insecticides applied are not effective

This list contains mostly **problems.** The high demand for vegetables is not, from the farmers' point of view, a problem but it appears to offer a **potential for a diversification** of farming.

Example 6.4: Screening

The initial list of problems and potentials (→ Example 6.3) is **checked and streamlined**:

(–) **Are the statements relevant and understandable ?**

- The term "Storage of maize", for example, neither points at a problem nor at a potential. A more appropriate statement would be "Storage losses of maize due to weevils";
- the statement "No fertilizer applied" points at the absence of a solution and not at the problem. The problem should be clear before a solution can be considered. The problem here may be rather the "nutrient deficiency of cotton and maize".

– **Is it possible to formulate more specificly ?**
A statement on problems or potentials should be as specific as possible in order to show leverage points for potential options. For example it would be useful for statement (4) to name the nutrients that are deficient, or to list the vegetables being in high demand in statement (9).

– **Are there any repetitions ?**
The initial list often contains a number of statements which describe the same problem or potential in different words. In our example, statements (7) and (12) are related: (12) is a cause of (7). Also (9) appears to be a cause of (4). (9) and (12) can therefore be dropped from the final list.

– **Are all problems and opportunities within the reach of research measures ?**
The final list should contain only such problems and opportunities which can be addressed through the means of agricultural research. The initial list will always contain topics which are obviously not within the influence of research measures (like statement (8) in our example). Such topics are omitted in the final list, but not completely discarded: they may be of relevance for the identification of available options. A "weak input supply structure" is, for example, not the ideal precondition for options requiring purchased inputs. Furthermore it may be constructive to mention such problems and opportunities to other more relevant aid organizations.

The results of the screening process is the final list of problems and potentials as shown blow:

Example 6.4: List of problems and potentials **(final list)**

1 Interplanted cowpeas entangle cotton	2 Storage losses of maize due to weevils	3 N & P deficiency of cotton and maize on sandy soil
4 Delayed 1st weeding affects yields of annual crops	5 Cashewnuts die for unidentified reason	6 Insect pests destroy cotton flowers and bolls
7 Citrus suffers from scab	8 High demand for onion, green pepper, carrots and kales	

Example 6.5: Digging deeper

The **"problem tree"** overleaf **presents graphically** the interrelationship between problems and their causes. It shows that

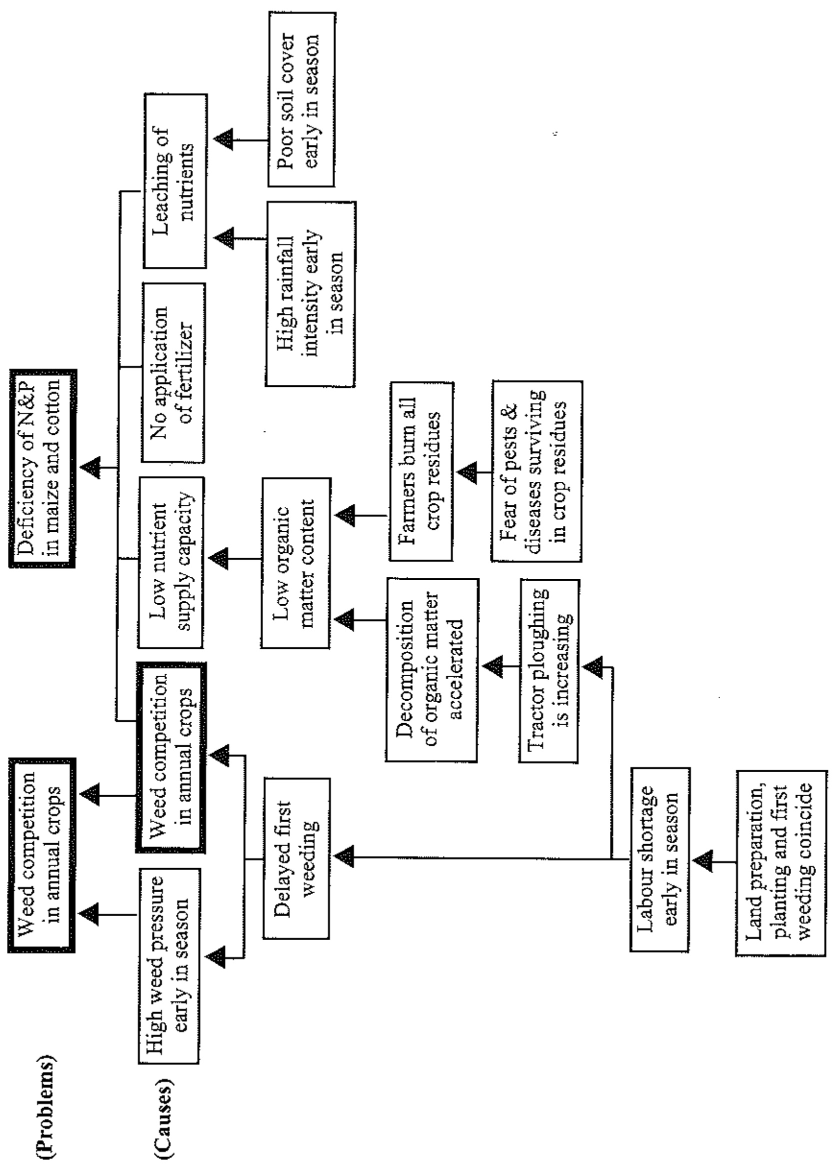
- there are usually several causes contributing to one problem; – a chain of causes may contribute to a problem;
- one single cause may contribute to several different problems (like "labour shortage" in the example);
- one problem may be a cause of another problem (as the "weed competition in the example).

The "problem tree" may pinpoint causes with a good chance of being solved through research efforts but it may also reveal factors that render a problem unsolvable with the given means.

The example of "N & P deficiency in maize and cotton" shows that there are sometimes several interlinked causes contributing to a problem. To solve the problem it will also require a number of different measures. A comprehensive analysis should be striven for in order to look into the right direction for possible options. Trying out fertilizer application alone would obviously not suffice in this case.

With farmers and field staff a **verbal summary** of the causes of stated problems is achieved more easily than the "problem tree". A verbal summary also facilitates the collection of additional information concerning identified potentials.

Example 6.5: "Problem tree"



Example 6.5: Verbal summary of additional information

High demand for vegetables is a chance for diversification, because
- the demand is unsatisfied after the end of long rains (July);
- there is a labour slack periode after weeding (June) until cotton harvest;
- the potential of periodically flooded depressions for recession cultivation is largely untapped.

Deficiencies of N & P in maize and cotton occur because of
- the low nutrient supply capacity of the soil, due to.....;
- the high weed competition early in the season, caused by...
-
-

III Analysis of variance and comparison of treatment means

Example 6.6: Analysis of variance and comparison of treatment means for a single factor experiment

Title: Cowpea varieties – Interplanting with cotton

Function: FACTOR
Data case no. 1 to 24
Without selection

Factorial ANOVA for the factors:
Variable 3 with values from 1 to 6
replicate 1-3
Variable 5 with values from 1 to 4
variety 1 = K80 2 = M66 3 = 577 4 = Local

Variable 7
cowpea yield kg/ha at 13% moisture

Grand Mean = 999.500 Grand Sum = 23988.000 Total Count = 24

TABLE OF MEANS

3 *	5 *	7	Total
1*	1*	1244.500	4978.000
2*	1*	1124.500	4498.000
3*	1*	1188.000	4752.000
4*	1*	730.500	2922.000
5*	1*	974.250	3897.000
6*	1*	735.250	2941.000
1*	1*	1311.833	7871.000
1*	2*	1202.333	7214.000
1*	3*	617.833	3707.000
1*	4*	866.000	5196.000

ANALYSIS OF VARIANCE TABLE

Code	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Rep	5	1016035.50	203207.100	2.77	.057
2	A	3	1813111.00	604370.333	8.25	.001
–3	Error	15	1098453.50	73230.233		

Coefficient of Variation = 27.07%

Example 6.6 shows the analysis of variance for a single factor experiment involving 6 farmers (variable 3) and 4 cowpea varieties (variable 5) as it is presented by MSTAT. The table of means presents in its **upper part** the mean cowpea yields **by farmer** and in the **lower part** the mean yields **by variety**.

The "Analysis of variance table" shows in line 2 that there are very highly significant treatment differences ("Prob = .001" is equivalent to the 0.1% level of significance). This experiment can not be analyzed for interactions between treatments and farmers, because there was no replication within farms.

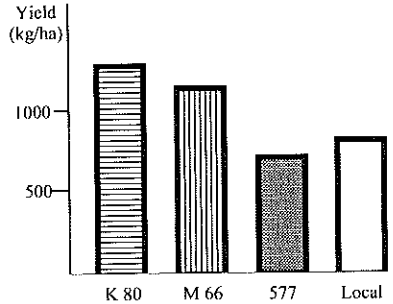
A pair comparison test, in this case "Duncans Multiple Range Test", was subsequently applied to analyze which treatment means differ from each other.

The results are presented in tabular form or as a bar chart. The letters behind the treatment means in the table denote significant differences between treatment means at the 5% level of significance: Any two means having a common letter are not significantly different at the chosen level of significance. The letters show K80 and M66 being significantly different from 577 and Local, whereas K80 and M66 as well as 577 and Local are not significantly different.

Table: Yield of cowpeas (kg/ha) Cowpea variety trial, LKSS 1992

Variety	Yield (kg/ha)
K 80	1310 a
M 66	1200 a
577	620 b
Local	870 b
Mean	**1000**

Figure: Yield of cowpeas (kg/ha) Cowpea variety trial, LKSS 1992



Example 6.7: Analysis of variance and comparison of treatment means for a full factorial experiment (wit non-significant interaction effects)

The following shows the table of means as it is produced by MSTAT and the analysis of variance table for a full factorial experiment on cotton and maize intercropping, involving two factors: Factor A being maize varieties with 2 factor levels (column 4 in the table of means) and factor B spatial arrangement of maize and cotton with 3 factor levels (column 5). 6 farmers participated in the experiment (column 3). Mean yields for **cotton** are shown in column 6.

TABLE OF MEANS, COTTON YIELD (kg/ha)

3*	4*	5*	6	Total
1*	1*	1*	1195.500	7173.000
2*	1*	1*	1228.167	7369.000
3*	1*	1*	495.667	2974.000
4*	1*	1*	1691.833	10151.000
5*	1*	1*	609.000	3654.000
6*	1*	1*	1274.500	7647.000
1*	1*	1*	847.056	15247.000
1*	2*	1*	1317.833	23721.000
1*	1*	1*	779.333	9352.000
1*	1*	2*	1175.833	14110.000
1*	1*	3*	1292.167	15506.000
1*	1*	1*	626.000	3756.000
1*	1*	2*	882.833	5297.000
1*	1*	3*	1032.333	6194.000
1*	2*	1*	932.667	5596.000
1*	2*	2*	1468.833	8813.000
1*	2*	3*	1552.000	9312.000

The first sector of the table of means presents the **mean cotton yields** by farmer, the second sector by maize varieties, the third sector by spatial arrangement and the fourth sector shows the mean cotton yields for all factor combination.

ANALYSIS OF VARIANCE TABLE

Code	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Rep	5	6064286.89	1212857.378	19.84	.000
2	A	1	1994685.44	1994685.444	32.63	.000
4	B	2	1734974.89	867487.444	14.19	.000
6	AB	2	127796.22	63898.111	1.05	.366
–7	Error	25	1528423.44	61136.938		

Coefficient of Variation= 22.84%

The analysis of variance table shows very highly significant treatment differences for factor A as well as for factor B. There was, however, no significant interaction effect between A and B. Spatial arrangement did, hence, not affect the results of maize varieties nor did maize varieties have an effect on the yields of the different spatial arrangements.

In this case the comparison of treatment means would be limited to the main factor effects, i.e. to the mean yields for the 2 maize varieties across all spatial arrangements and the mean yields of the spatial arrangements across both maize varieties. A pair comparison test will be required only for the 3 spatial arrangements, as the F-test already proves that the effects of the 2 maize varieties were significantly different. A comparison of all factor level combinations is not appropriate if the treatment interaction is not significant.

Without significant interaction effects also the presentation of results can be restricted to the main factor effects:

Table: Cotton Yield (kg/ha)
Maize variety x cotton spacing trial, LKSS 2

a) by maize variety	Cotton yield
Coast composite	850
Pwani hybrid	1320
b) by spatial arrangement	
Arrangement 1	780 b
Arrangement 2	1180 a
Farmers arrangement	1290 a

Example 6.8: Analysis of variance and comparison of treatment means for a full factorial experiment (with significant interaction effects)

The following analysis of variance table was computed for a full factorial experiment on cowpea interplanting into cotton, with 2 factors: factor A being cowpea varieties with 4 factor levels and factor B cowpea time of interplanting into cotton with 2 factor levels. 3 farmers participated in this experiment.

ANALYSIS OF VARIANCE TABLE

Code	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Rep	2	94782.33	47391.167	1.63	.231
2	A	3	780.46	260071.486	8.93	.001
4	B	1	8742.04	8742.042	64.18	.000
6	AB	3	1016454.46	338818.153	11.64	.000
–7	Error	14	407641.67	29117.262		

Coefficient of Variation = 31.94 %

The ANOVA-table shows very highly significant treatment differences for factors A and B as well as very highly significant **interaction effects between factors**. The comparison of means for the main factor effects can be misleading if the interaction effects are significant. Instead the comparison of means is done for the **factor level combinations**. A suitable tabular representation of results would be a two way table:

Table: Yield of cowpeas (kg/ha) interplanted with cotton by cowpea variety and time of interplanting

Cowpea Variety	Time of cowpea interplanting	
	Same time as cotton	Farmers Time
K 80	1070 ab	290 c
M 66	1160 a	210 c
577	840 b	220 c
Farmers'	170 c	310 c

Note: A mean comparison of all possible treatment means would not be appropriate. Only **pairs of means within the same row or within the same column** are being compared.

Example 6.9: Analysis of variance and comparison of treatment means for an experiment with location (site) as an experimental variable

The following analysis of variance table was calculated for a cowpea variety trial including four cowpea varieties. The trial was carried out at two villages with three farmers per village. "Location" (or village) was included as experimental variable in the analysis of variance.

ANALYSIS OF VARIANCE TABLE

Code	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Location	1	831792.67	831792.667	18.06	.013
2	R(L)	4	184242.83	46060.708		
4	A	3	1813111.00	604370.333	18.02	.000
6	LA	3	695983.00	231994.333	6.92	.005
–7	Error	12	402470.50	33539.208		

Coefficient of Variation= 18.32%

The ANOVA-table shows significant treatment differences. It also indicates a significant **interaction effects between treatments and locations** (varieties K80 and 577 responded strongly to the different environments, the other varieties did not).

The results are presented in a two-way table similar to that of the full factorial experiment. Pair comparisons are again appropriate only for values within the same row or within the same column.

Table: Yield of cowpeas (kg/ha) interplanted with cotton by cowpea variety and location

Cowpea Variety	Trial Location	
	Mpeketoni	Hindi
K 80	1560 a	1090 bc
M 66	1240 ab	1140 bc
577	1060 bc	180 d
Farmers	890 bc	840 c

The significant interaction effects between varieties and locations means that the varieties behaved differently at the different locations. In a subsequent step the factors need to be identified which contribute to the interaction between varieties and locations.

Note: Procedures and interpretation for analysis of variance across villages (or locations), farmers or seasons follow the same pattern.

IV Nonparametric tests to determine differences with regard to farmers assessment of experimental treatments

Example 6.10: Friedman's test

Problem: Four treatments were rated or ranked by ten farmers. Do the treatments differ from each other according to their scores?

The table below shows the overall ranking of four cowpea varieties carried out by ten farmers. Friedman's test analyses whether differences occur between treatments concerning the scores given.

Table: Overall ranking of four cowpea varieties by ten farmers (Rank 1 = best, rank 4 = worst)

Farmers	Treatment			
	K 80	M 66	577	Farmers
1	1	2	4	3
2	2	3	4	1
3	1	2	3	4
4	2	1	4	3
5	2	4	1	3
6	1	2	4	3
7	2	1	3	4
8	1	3	4	2
9	3	1	2	4
10	1	2	4	3
Rt	16	21	33	30
Rt^2	256	441	1089	900
Median	1.5	2	4	3

The test value X^2 is calculated as follows:

$$X^2 = \left(\frac{12}{k \cdot n \cdot (k+1)} \cdot \sum Rt^2\right) - 3 \cdot n \cdot (k+1)$$

k = *number of treatments*

n = *number of farmers*

Rt = *Sum of scores by treatment*

Therefore:

$$X^2 = \left(\frac{12}{4 \cdot 10 \cdot (4+1)} \cdot (16^2 + 21^2 + 33^2 + 30^2)\right) - 3 \cdot 10 \cdot (4+1)$$

$$\Rightarrow X^2 = 11.16$$

X^2 is compared with the tabular Chi-square value with k-1 = 3 degrees of freedom. Chi-square is 7.81 at p=0.05. X is larger than the tabular Chi-square, therefore it can be concluded that there are significant differences between the varieties with regard to their ranking by farmers.

When values to be analysed result from a rating using a defined rating scale or from measurements, they have to be transformed to ranks in order to calculate Friedman's test value. This ranking is done by giving the smallest value rank 1, next highest value rank 2 and so on. Scores with equal value get an average rank.

Note: In this example the number of farmers was only ten in order to make the calculation transparent. ten farmers is of course to little for a representative assessment. 30–50 representative farmers would be more appropriate (see also Chapter 5.2.6.1).

If Friedman's test yields a significant test value, multiple comparisons of treatments can be carried out for instance with the help of the Wilcoxon-Wilcox test.

Example 6.11: Q-test

Cochran's Q-test is a special case of Friedman's test configuration when data exist only in two categories (dichotomized data: yes-no, adopted-not adopted etc.). This is for instance the case when individuals get confronted with a number of treatments and the presence or absence of some attribute is observed (for instance accept – refuse).

Problem: Are treatments differently adopted by farmers ?

The following table shows the results of an adoption study on three cowpea varieties done with ten farmers. If a treatment was adopted by a farmer it is marked with a "+" sign, if not a "-" sign is used.

Table: Adoption and non-adoption of three cowpea varieties by ten farmers one season after trial implementation ("+" = adopted, "-" = not adopted)

Farmer	Treatment			Li	Li^2
	K 80	M 66	577		
1	+	+	–	2	4
2	+	–	–	1	1
3	+	+	–	2	4
4	+	+	–	2	4
5	+	–	+	2	4
6	+	+	–	2	4
7	+	+	+	3	9
8	+	–	–	1	1
9	–	+	+	2	4
10	+	+	–	2	4
Tj (= no. adopted)	9	7	3	$\sum Li = 19$	$\sum Li^2 = 39$
% adopted	90	70	30		

The test value Q is calculated as follows:

$$Q = \frac{(k-1)\cdot(k\cdot\Sigma Tj^2 - (\Sigma Tj^2))}{k\cdot\Sigma Li - \Sigma Li^2}$$

k = *number of treatments*

n = *number of farmers*

Tj = *number of positive reactions per variety (how many farmers adopted a particular variety)*

Li = *number of positive reactions per farmer (how many varieties were adopted by a particular farmer)*

(***n · k should be*** **>23!**)

Therefore:

$$Q = \frac{(3-1)\cdot(3\cdot 139 - 361)}{(3\cdot 19) - 39} = \frac{112}{18}$$

$$\Rightarrow Q = 6.22$$

Q is compared with the tabular Chi-square value with k-1 = 2 degrees of freedom. Chi-square is 5.99 at p=0.05. Q is larger than the tabular Chi-square, therefore it can be concluded that there are significant differences between the varieties with regard to their adoption by farmers.

The Q-test is also suitable to **test changes in adoption habits**. It could be of interest to test if the adoption rate concerning a specific treatment changes over time.

If the treatment is accepted by a farmer a "+" sign is given,

if the treatment is not accepted by the farmer a "-" sign is given.

Table:

Farmer	Year					
	1	2	3	4	• • • •	m
1	+	+	+	–	• • • •	
2	+	–	–	–		
3	+	+	• •			
•						
•						
•						
N	• •	• •	• •	• •	• • • •	

Example 6.12: Analysis of frequencies in two way tables (independent samples)

Problem: Is there a relationship between specific target group characteristics (such as affiliation to a defined income, age or ethnic group) **and preference for a particular treatment** (only the best ranked treatment is counted) ?

This problem can be solved with the Chi-square statistics.

Income groupe	Treatment 1	2	3	• • • •	Ri
1	f11	f12	f13		R1
2	• • •	• • •	• • •		R2
3	• • •	• • •	• • •		• • •
• • •			fij		
Cj	C1	C2	C3	• • • •	N

Ri	=	*Row totals*
Cj	=	*Column totals*
N	=	*Sample size (total number of observations)*
fij	=	*observed cell frequencies (i.e. f 11 = number of people in income group who prefer treatment 1 ...)*

The expected frequencies (eij) have to be calculated for every cell:

$$eij = Ri \cdot Cj \cdot \frac{1}{N}$$

$$\text{Ci-square test value} = \Sigma \frac{(fij - eij)^2}{eij}$$

with $(c-1)\cdot(r-1)$ degrees of freedom.

The test value is compared with the respective value of the Chi-square distribution.

Annex 6.2: Brief software overview (by H.G. Schön, STATITCF by W. Graf)

MSTAT

MSTAT-C is an integrated microcomputer program specifically designed for agricultural research. It is intended to help the researcher through all stages of experimentation.

MSTAT is a menue driven program which generates experimental designs, manages and transforms data and analyzes trials from both a biological and an economical perspective. It provides applications like trial design, field books, descriptive statistics, cross tabulation, t-test, ANOVA, nonorthogonal analysis of variance, range tests, nonparametric test, correlation and regression, economics, etc. The economics subprogram follows the procedures described in the CIMMYT manual "From Economic Data to Farmer Recommendations" (see Literature). The graphical facilities of MSTAT are not as powerful as those of other programmes described.

MSTAT imports and exports ASCII files. Data can be entered also through the integrated spreadsheet. MSTAT is easily installed and relatively user friendly.

MSTAT requires an IBM compatible PC with a minimum of 512 K RAM, MS-DOS and a hard disk. MSTAT is very reasonably priced.

Dialogue language: english.

Distributor: Michigan State University, MSTAT/Crop and Soil Sciences, A87 Plant and Sciences, East Lansing, Michigan 48824, USA

SOLO

SOLO Version 4.0 provides a wide range of statistics from descriptive to multivariate (descriptive statistics, cross tabulation, t-tests, ANOVA, GLM, ANCOVA, linear and nonlinear, simple and multiple regression, nonparametrics etc.) as well as an array of data management and transformation capabilities.

SOLO creates and prints a wide range of statistical graphics with strong exploratory features and presentation graphics in reasonably good quality. The graphics options interface thoroughly with the statistical portion of the package. The package is fully menue-driven and uses "fill in the panel" technique. The panels allow to quickly define the options to customize the analysis. With the panels you are presented with all the options at once. One can move around with the cursor to the fields and a "help" message with all the options for that field becomes visible.

SOLO allows to store up to 500 variables and 30 observations on a data base. Formatted in a spreadsheet fashion, the editor enables easy data management. Data can be imported and exported (ASCII-format and important spreadsheet formats). SOLO does not offer any capabilities to conduct specific economic analyses. Data processing of voluminous data sets (1000 records) gets increasingly slow when complex procedures are used.

The program is easily installed. SOLO requires an IBM PC or compatible, with 512 K of RAM, about 4 MB hard disk space and MS-DOS. SOLO is available in various dialogue languages and very reasonably priced.

Distributors:BMDP Statistical Software, 1440 Sepulveda Blvd., Los Angeles, CA 90025, U.S.A.

in Europe: Cork Technology Park, Model Farm Road, Cork, Ireland

SPSS/PC+

SPSS/PC+ derived from the main-frame and is a modular, interactive program. The program contains several modules: Base, Statistics, Advanced Statistics, Tables, Trends, Categories, Graphics, Mapping and Data Entry II. The modules Graphics and Mapping of the PC-version are interfaces; the module Graphics needs Harvard Graphics or MS-Chart as enhancement, the module Mapping works together with MapInfo or PC-MAP. SPSS/PC+ has strong statistical capabilities, a very good handling of missing data, batch capabilities and can process large data sets in a speedy way. On the other hand SPSS/PC+ demands a capable hardware configuration, especially a lot of hard disk space.

SPSS/PC+ is available for IBM PC's or compatibles and APPLE Macintosh. Besides the MS-DOS version an SPSS for WINDOWS version is meanwile offered. SPSS/PC+ is available in various dialogue languages. Since it is a very powerfull statistical package it is quite expensive.

Distributor: SPSS Inc., 444 N. Michigan Avenue, Chicago, Illinois 60611 U.S.A.

SYSTAT/SYGRAPH

SYSTAT/SYGRAPH version 5 is a comprehensive statistics, graphics, and data management package for IBM/compatible (MS-DOS and WINDOWS version) and Macintosh. This package offers a full range of univariate and

multivariate statistical procedures and a great number of two- and three-dimensional graphics for scientific and statistical applications, including dynamic 3-D data plot spinning. SYSTAT is basically command driven, but offers a menue facility, which works quite slow.

Distributor: SYSTAT Inc. 0 Sherman #801, Evanston, Illinois 60-3793 U.S.A.

STATITCF

STATITCF is a microcomputer software designed specifically for agricultural research. It is fully menu driven and has an extensive help feature. It has therefore a high value for teaching purposes. It features cross tabulation, ANOVA, t-test, non-parametric statistics, mean separation tests, principal component analysis, analysis of time series, regression and multidimensional ANOVA.

STATITCF imports and exports ASCII, DBase^{3+}, Lotus and other DIF-files. Data can also be entered through the STATITCF-spreadsheet, but only 60 variables can be handled directly. The graphic feature is modest.

The programme requires an IBM compatible PC with DOS, 512 K RAM and 10 Megabite hard disk space. It is reasonably priced. It is available with french dialogue language only and widely used in francophone tropical countries.

Distributor: Institut Technique des Cereales et des Fourrages,
8,Av. du President Wilson, F-75116 Paris, France

Worksheet programs

Common Worksheet programs offer a wide range of spreadsheet functions , data base management possibilities and have powerfull presentation graphics abilities. Worksheet programs are very handy for preparing matrices for the analysis of trials and surveys. They offer, however, also basic statistical functions like mean, standard deviation, variance etc. and simple and multiple regression. The data can be presented in two- and three-dimensional graphics display. Popular displays used in descriptive statistics are available. Important transformations are offered. Quite a number of functions deal with cross-tabulation, but Chi-square statistics is not included. These packages are in general handy.

A key to statistical methods and to what different computer programmes can do

(I) Measurement Variables (normal Distributed)	Purpose	Method	Software (- Module)
1 variable 1 treatment	Examination of a single sample	Arithm. mean, Standard dev., Standard error, Confidence limits, Histogram	SOLO – Descr. Statistics SPSS, SYSTAT, MSTATC, STATITCF, EXCEL, LOTUS 123 etc.
1 variable 2 treatments	Independant variates	T-test	SOLO, MSTATC; STATITCF, SPSS, SYSTAT, MSTATC, EXEL, LOTUS 123
	Paired variates	Paired comparisons test	SOLO, MSTATC, SPSS, SYSTAT, STATITCF
1 variable ≥ 2 treatment	Single classification	one-way-ANOVA	SOLO – ANOVA – GLM ANOVA SPSS – ANOVA, MANOVA MSTATC, STATITCF, SYSTAT
	Block design and multi way classification	Multi-way ANOVA	SOLO – GLM ANOVA – ADVANCED SET SPSS – MANOVA MSTATC, SYSTAT, STATITCF
	Comparison among means	Mean separation procedures	SOLO, SPSS, SYSTAT, MSTATC, STATITCF
2 variables	Prediction of functional relationship	Regression statistics	SOLO – GRAPHICS MENUE – REGRESSION SPSS, STATICTCF, SYSTAT, MSTATC, EXCEL, LOTUS 123 etc.
	Association	Pearson's correlation coefficient	SOLO, SPSS, SYSTAT, MSTATC, STATITCF, EXCEL, LOTUS 123 etc.
≥ 3 variables	Prediction of functional relationship	Multiple regression	SOLO, SPSS, SYSTAT, MSTATC, STATITCF
	Association	Coefficient of multiple correlation, Coefficient of partial correlation	SOLO, SPSS, SYSTAT, MSTATC, STATITCF

(II) Ranked Variables (also Measurement Variables Without Normal Distribution)	Purpose	Method	Software (- Module)
1 variable 1 treatment	Examination of a single sample	Median	SOLO, SPSS, SYSTAT, MSTATC, EXCEL, LOTUS 123 etc.
		Box-and-Whisker plot	SOLO, SPSS, SYSTAT
		Frequency distr. and other diagrams	SOLO, SPSS, SYSTAT, MSTATC, STATITCF, EXCEL, LOTUS 123 etc.
1 variable 2 treatments	Independant variates	Mann-Whitney-Test	SOLO – NONPARAM. STAT., SPSS, SYSTAT, MSTATC
	Paired variates	Wilcoxon's signed ranks test	SOLO – NONPARAM. STAT., SPSS, SYSTAT
1 variable ≥ 2 treatment	Single classification	Kruskal-Wallis test, Nemenyi test	SOLO – NONPARAM. STAT., SPSS, SYSTAT
	Two way classification	Friedman's test	SOLO – NONPARAM. STAT., SPSS, SYSTAT
2 variables 1 treatment	Association	Coefficient of rank correlation	SOLO, SPSS, SYSTAT
≥ 3 variables 1 treatment	Association	Kendall's coefficient of concordance	STATITCF

(III) Attributes	Purpose	Method	Software (- Module)
1 variable 1 treatment	Examination of a single sample	Diagrams	SOLO – GRAPHICS MENUE, SYSTAT, STATITCF, EXCEL, LOTUS 123 etc.
1 variable ≥ 2 treatments	Single classification	Chi-square statistics	SOLO, SPSS, SYSTAT, MSTATC, STATITCF
	Two way or multi-way classification	Log-linear models, Q-test, McNemar-test	SOLO, SPSS, SYSTAT, MSTATC
2 variables	Association	Chi-square statistics, G-test	SOLO, SPSS, SYSTAT, MSTATC, STATITCF
≥ 3 variables	Association	Log-linear models	SOLO, SPSS, SYSTAT