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

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	Verification
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.

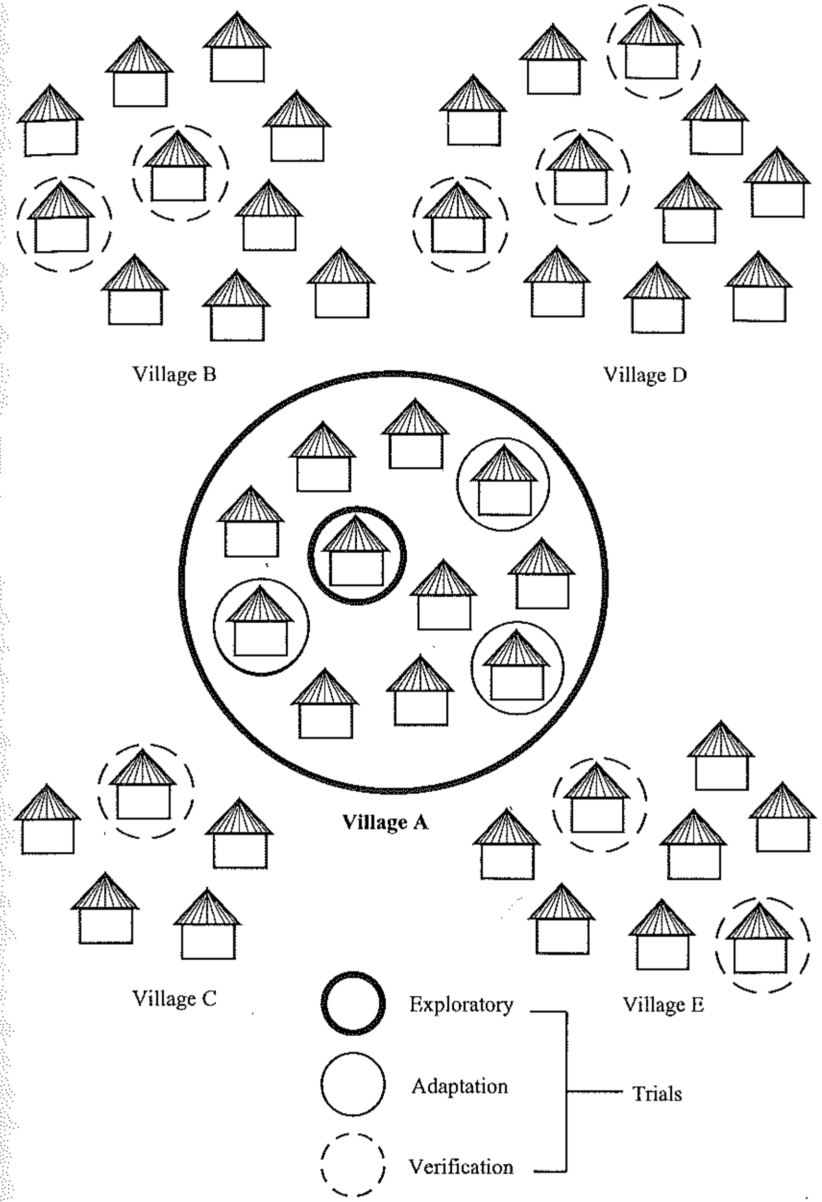
In a **representative village approach** a small number of villages are chosen which represent the natural as well as the socio-economic conditions of the programme area. A practicable procedure is to define zones with relatively homogeneous natural and socio-economic conditions (see Chapter 2.4.3) and 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.

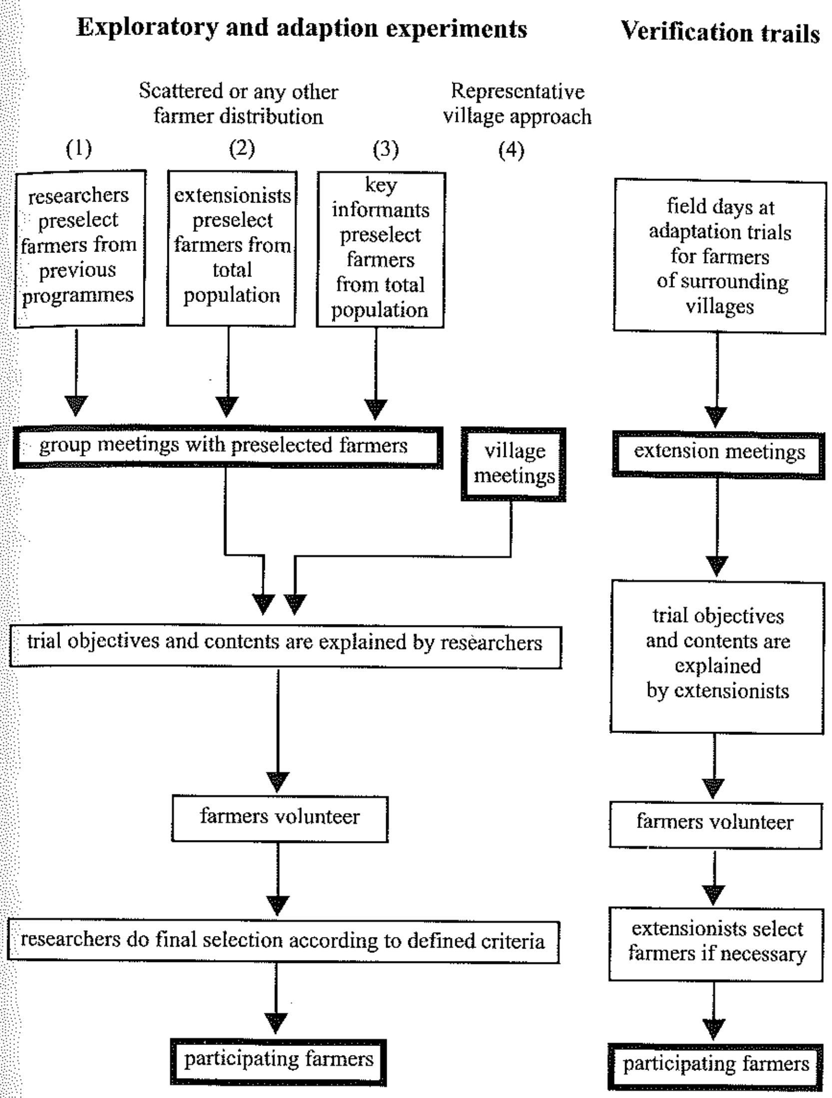
A broader participation of farmers is aimed for in the **verification phase** of a trial. One practicable approach for farmers' selection is shown in Figure 5.4. During the adaptation phase of a trial, farmers of the surrounding villages are invited for field days to discuss objectives, contents and 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

On-Farm-Trial – Trial Report Page 1

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)			

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(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? ____________

____

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(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) ____

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– 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