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OPTIMIZING POTATO PRODUCTIVITY
PLANNING AND IMPLEMENTING ON-FARM TRIALS

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I. Introduction

In CIP's approach for optimizing potato productivity (OPP) on-farm trials are considered as experiments where an alternative technology (selected for its potential for improving yields and/or incomes) is compared with the farmer's current practice. This comparison takes place in the farmer's field using his inputs and facilities.

The alternative consists in one or several changes in the crop production system. Testing this alternative helps determine if these changes produce the expected agro-economic improvements to the crop. For these reasons, the selected changes constitute the only differences between the various plots of the comparison experiment.

Theoretically an on-farm trial will be composed of two basic experimental treatments:

Treatment F: In which farmer's production technology is applied without any alterations or changes. In fact this treatment can be represented by any part of the farmer's field.

Treatment A: In which selected changes are introduced into the farmer's crop production system. The production factors covered by these changes constitute the only factors that vary between treatments F and A, all the other factors are maintained at the level of treatment F. In other words treatment A will follow the farmer's technology except for those factors selected for modification.

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* This paper forms part of a series of training documents related to CIP's approach to optimizing potato productivity. This document, therefore, deals only with the execution of trials. Methods dealing with identification of farm-level constraints, economic analysis, and other crucial steps in the OPP strategy are detailed in other training documents.

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As indicated in the overall description of the OPP approach, the on-farm trial phase follows the identification of alternatives to the present crop production system. In other words, before the actual planning and implementation of the trials, the research must have very clearly identified the changes to introduce into the farmer's crop production system. The on-farm trials will test these changes as to their relevance for improving the farmer's yields and/ or incomes. These tests are conducted in a sizable number of farms selected within the study area.

This training document covers the practical aspects of the preparation of the trials (planning), their installation and follow-up (implementation and data recording). It ends with a concrete example to illustrate the three parts previously described.

II. Planning of the Trials

Good planning of on-farm trials requires listing and answering a series of questions relevant to the implementation of the trials. The efficiency of planning depends on completeness of the listing and the adequacy of the answers. Experience with on-farm research for optimizing potato productivity indicates that the most important questions can be grouped as follows:

1. Definition of the trials.

2. Execution of the trials.

3. Follow-up of the trials and recording of data and information.

4. Analysis and interpretation of the results.

Several important questions and their answers are interrelated. Hence, the listing and answering process should be considered as a whole, and should be done at an early stage in the research, as soon as possible after decisions have been reached as to the technological alternatives to be tested. The adequacy of the answers is highly dependent upon knowledge the researcher has about the selected area and the target group for on-farm research. This knowledge helps avoid decisions that may be unrealistic once the implementation of the trials is initiated.

To illustrate the variety of questions to be answered, we list below some of the major questions under each of the four groups mentioned above.

1. Definition of the Trials

a. What is (are) the experimental variable(s)? They must be clearly and precisely defined in contrast with the farmer's current technology. In other terms the changes introduced into the farmer's production system must be precisely defined leading to a clear understanding of "Treatment A" in comparison with "Treatment F."

b. How many variables (or technological changes are going to beincorporated in each alternative? and how many alternatives are we going to test in each experimental site (farm)? Are we sure that the changes we have defined are the only ones we are introducing, or are others creeping in as well. For example, we can plan a trial where the seed source is the unique change introduced but if we decide to actually plant the trial (instead of the farmer) we might introduce some unforseen changes such as planting density and method and end up attributing to the seed sources results that are partly due to the density and/or the planting method.

c. On how many farms will we conduct a given type of trial? Do we have the facilities to properly conduct the chosen number of trials? Our decision should ensure best use of our facilities. Often a reduction of the number of alternatives to be tested or their simplification permits an increase in number of testing sites, thus increasing the degree of confidence in the testing process.

2. Execution of the Trials

a. In which agro-ecological zone (target area) and with what type of farmers (target group) within this zone are we going to conduct the trials?

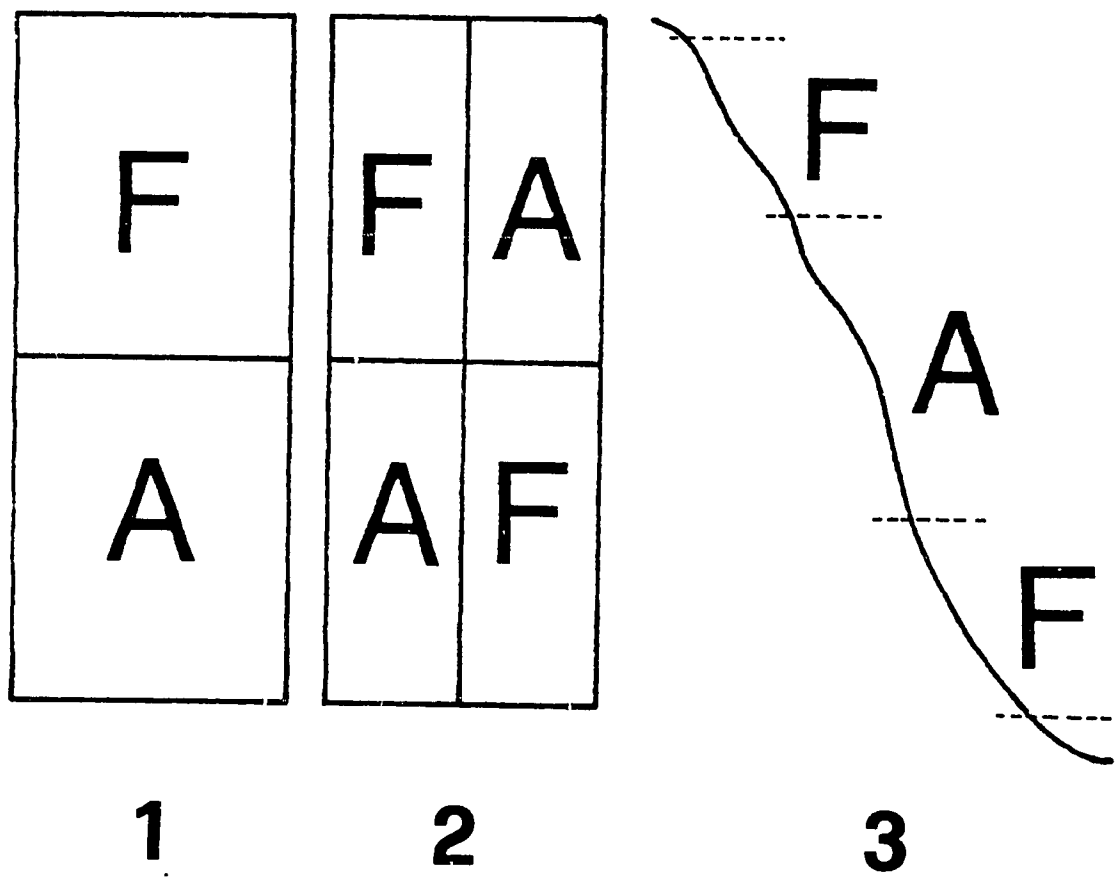
b. How will we select the collaborators? For their willingness to host a trial, their awareness of the production problem treated by the trials or because they are representative of the target group within the study area?

c. Where on each farm will we locate the trial? In the best potato field? In the one closest to the road? This decision is of major importance especially in mountainous areas where the risk faced by the farmer (and consequently the level of his willingness to invest in costly inputs) varies with the position of the field along the hillside.

d. What is to be the size of each experimental plot? Are we to adopt a standard size throughout all sites or do we define a minimum area and decide to increase it every time the configuration of the field allows it?

e. What experimental design will be used? Adjacent comparison plots or a special design to avoid biases due to topography of the fields?

The following figure shows the three designs most commonly used in the implementation of potato on-farm trials during the past 2 years:



- Design No. 1 consists of two adjacent plots within a potato field. It is adequate for flat, reasonably level fields.

- Design No. 2 is a 2 X 2 Latin square design useful in hilly areas where planting lines do not coincide with contour lines.

- Design No. 3 consists of a central plot (in which the alternative technology is applied) adjoined by two control plots, that is useful where the planting lines and contour lines coincide.

f. When should we plant and harvest the trials? The same day the farmer is planting/harvesting or a day or two earlier? Given the importance of the involvement of the farmer in on-farm research, the choice of the two "key dates" should ensure the presence of the collaborator. Besides it is important to conduct the trials without upsetting the farmer's usual operations and also avoiding the errors that will probably creep into the trials when planted or harvested in the middle of the "rush" of the farmer's current operations.

g. Who will execute which operations? The farmer, the scientist or both? Ideally the farmer should conduct all the cultural operation in the trial especially for those practices that do not vary between the alternative tested and the farmer's present production system. For those practices that will be changed by the alternative tested the preceeding principle remains valid but the scientist must supervise the operation making sure that it is applied with the desired precision, at the selected time and in an adequate manner. Only in a few "delicate" cases should the scientist perform the practice on behalf of the farmer.

h. Who will pay for what? Is there a need to provide the farmer collaborator with an incentive and to what extent? Again, the ideal is the farmer himself financing the trial which would be clear proof that he is concerned by the problem the trial is attempting to solve. In reality, things do not work so smoothly and often some incentive is needed to obtain the full cooperation of the farmer. Nevertheless this incentive should be applied very carefully so as not to "buy" the willingness of the farmer regardless of the problem being considerated or the technology being tested.

i. What practical procedures is the installation, execution and harvest of the trial going to follow? This is a very important aspect since any "improvisation" at any stage might lead to unforseen biases and introduce differences between trials that initially were planned to be similar. This uniformity of procedure becomes crucial when several operators are conducting a group of trials. The fewer "on the spot" decisions the implementer(s) must make, the greater is the uniformity and reliability of a given series of trials.

3. Follow-up of the Trials and Recording of Data and Information

a. How often should each trial be visited? The number of visits will depend not only on the facilities available but also on the number and complexity of the trials, the data and information to be recorded. Regularity of visits is as important as precise planning, especially for visits during which a specific type of data must be recorded.

b. What information should we communicate to the farmer before the installation of the trial and what aspects should we discuss with him during the follow-up visits? Exchange of views with the farmer collaborator is often a rewarding process. However, the researcher must have

in mind clear issues to be discussed or he will end up with a large quantity of information that will be difficult to structure and utilize.

c. What type of data should be recorded in the field, in the market and elsewhere? When is each type of data recorded? How and according to which specific qualitative criteria recorded? This important issue will be covered in Section IV of this training document. For the time being it is important to keep in mind that the data recording process needs careful and advance planning like all other aspects of on-farm research.

4. Analysis and Interpretation of the Results

a. What type of agroeconomic analysis will we do for each of the trials? To answer this question the research must clearly define the alternative being tested and consequently list the agronomic and economic data that show the effect of the alternative and help in determining its agroeconomic efficiency. The clear definition of the analysis of results will aid the scientist to make sure all the data needed is recorded at the right time while avoiding omissions or superfluous information. The same precautions are valid for "non quantifiable" information gathered around each trial and concerning the farmer's perception and appreciation of the alternative technology tested.

b. How to combine or "put together" the results of a series of trials testing the same alternative? The overall interpretation of the trials is an essential step to determine the adequacy of the alternative tested for improvement of the farmer's yields and/or income. Thus advance planning for overall interpretation is an important aspect to permit the scientist to prepare the information needed at the end of the evaluation process.

The above is not a comprehensive check list and can often be modified to match specific trials and technologies. It gives an idea of the types of questions that must be answered before starting the trials. Clear answers are needed prior to field trials to avoid problems that may be difficult or impossible to solve once the on-farm research has started. Advance planning and standardization of procedures is crucial in cases where several operators are sharing implementation of the trials.

III. Implementing On-Farm Trials

Starting on-farm trials follows these four major steps:

1. Development of a "cooperation agreement" with the farmer.

2. Installation of the trial.

3. Follow-up of the trial.

4. Harvest of the trial and sharing results with the collaborator.

Normally, and if proper attention has been given to the planning phase, the actual implementation should not raise unsurmountable problems especially for persons who have learned to deal with farmers, speak their language and have a feel for their situations. Poor planning (missed questions or unrealistic answers) results in greater difficulties for the implementation phase. The following "practical" points are a result of our recent experience in this field.

The "cooperation agreement" with the farmer

The agreement must be very clear in its terms. The "joint research venture" should be made clear to the farmer and its potential results related to the problems he is facing. If the trial appears of mutual interest to both farmer and researcher, then obligations of each party can be clearly delineated and will have a better chance of being met by the collaborator. The general agreement on goals and principles will be supplemented by a detailed listing of calendar of events, distribution of roles as far as the different cultural practices are concerned and, finally, a list of the financial contribution (money, inputs, labor) of each party.

By agreement we do not necessarily mean a written contract but a "moral engagement" that will tie together two collaborating parties for the achievement of a common goal.

In deciding upon the dates (such as planting, special practices, harvest) or in defining the contributions, the researcher must be certain that he is not deeply upsetting the farmer's current operations. The collaborator is expected to make an effort while accepting the trial but this effort should remain reasonable and realistic -otherwise the collaborator will not follow.

Installation of the trial

The trial should be thoroughly prepared so that it can be installed as quickly as possible A basic principle is to minimize the measuring operations to be done in the field. For example, the scientist will arrive with his inputs ready (counted, weighted ...) so that the only measurements to be actually done in the field will concern the farmer's inputs, labor and land utilized.

The shape and area of the different experimental plots, their position in the field are highly dependent on the technology to be tested. Not all technologies will require square, precisely measured equal plots. In several cases two consecutive stripes (not necessarily equal in width) covering a portion (or the whole) length of the field will be

adequate. The easiness by which the experimental plots can be installed will play a determinant role in their choice.

In delimiting the plots take care to use marks or stakes that will not interefere with farming operations while at the same time, will not be easily lost or displaced. Often marks outside the field (a tree, well, wall ...) and their distance or position to one corner of the trial, will be useful.

Finally, an important aspect of the installation of an on-farm trial is the punctuality of the researcher. The farmer cannot (and should not) wait for the scientist in order to start a given operation. Farmers are early risers, for example, and the scientist should adapt.

Follow-up of the trial

The follow-up of the trial, while necessary for data recording and information gathering, must also note the execution of cultural practices that are part of the alternative technology. The same basic principles mantioned for installation of the trial are valid for the follow-up minimizing the number of measurements, rapidity, punctuality or others. Visits are used to discuss with the farmer the implications and results of the proposed technology. Some data do not necessarily need recording in the presence of the farmer and may be done after or before a visit to the trial with the cooperator. Nevertheless the scientist must at least point out to the farmer those aspects that characterize the response to the proposed alternative.

Harvest of the trial and sharing the results with the collaborator

Depending on size of plots in a given trial and according to type of technology tested, the scientist decides whether to harvest all or only a portion of each plot. Normally if the plots are of a reasonable size (100-200 m^2) the border effect is minimized and the totality of the plot can be harvested. This reason, plus easier observation and accessibility to the farmer, should encourage the scientist to work in sizable plots (more than 100 m^2) whenever possible. If large strips are used then the scientist may decide to harvest several sample sub-plots within the strip. These sub-plots are selected at random and their combined area should be large enough to give reliable results (100 m^2 or more). At harvest the researcher collects data concerning total yields of the alternative technology and the farmer's current practice (yields of plots A and F of the basic design). The total yield figures are often insufficient because they can not lead to a clear estimate of the value of the crop. This is why this total yield must be supplemented by data reflecting the quality of the production (percentage of damage due to pathogens, or pests, percentage of different grades....). This qualitative classification should be done according to the farmer's criteria and performed by him at least for the first samples harvested.

Results of the trials should be presented to the farmer first at harvest in the field. If possible they should be discussed with him again later during a more relaxed meeting where the scientist can also present results of similar trials from other locations. Monitoring the reaction of the farmer to the proposed technology is a continuous job and probably as important as gathering figures on yields, costs and incomes.

In summary the implementation of on-farm trials is governed by a basic concern: maintain a good working relationship with the farmer collaborator to minimize the trouble caused by the intrusion of on-farm research into his day to day operations, and also to get as close as possible to his honest evaluation of the alternative technology tested in his field.

IV. Recording of Agronomic Data

This section covers only collection of agronomic data concerning each of the trials. Collection of economic data and of information concerning the farmer's evaluation of the alternative technology will be covered in other training documents.

By agronomic data we mean those parameters that:

a. Characterize the alternative technology in contrast with the farmer's present practice (for example, seed rate, fertilization, planting method, seed preparation).

b. Indicate the differences induced by the alternative technology into the crop: (such as rapidity and uniformity of emergence, pest and disease incidence, earliness of the crop, soil coverage, stem density, yield, quality).

Because characterization of the alternative and its effects are to be compared with those of the farmer's practice, the data recording process is basically a dual system where each type of observation is done twice: once for the farmer's practice and once for the alternative tested. Thus it is necessary for the scientist to have a clear understanding of the changes he is attempting to introduce into the farmer's current practice, and of the expected effects of these changes on crop development and yield. The clearer this understanding the easier the choice of the parameters to be covered by the data recording process.

In reality the scientist will chose those parameters that he will use in the interpretation and evaluation of the results of a series of trials. The definition of the evaluation procedures will help restrict the recording of data to those observations that are actually used in following various steps of the research. This restriction is essential since any time saved could be used to expand the number of testing sites thus reinforcing the value of the research.

The other aspect to consider is the definition of procedures followed while performing the different measurements. This includes, for example: the definition of the sample selected (observe such characteristicson how many plants per plot), a clear scale for disease incidence, a procedure to measure rapidity and uniformity of emergence (count number of emerged plants at 50, 60, 70 days and relate to original number of tubers or unit area), a procedure to measure extra inputs used at planting or crop care, and others.

The definition of the measurement procedures is essential but it becomes crucial when several operators are involved in implementation of the trials.

These procedures will include indications on when each specific type of data needs to be recorded. The timing of the recording is essential, especially for those observations related to crop development, disease incidence and specific punctual cultural practices.

In practice, we have always found it extremely important to design especial data recording sheets for each series of trials. Basically these sheets consist of two columns for each class of data: one for the alternative and one for the farmer's practice. These sheets can be improved drastically by another explaining specific procedures and timing indications for the recording process.

While focusing data recording on differences between the farmer's practice and the alternative technology, the scientist must be alert to note any specific data (that was not viewed during the planning process) which might help explain the results of the trials. At the same time the scientist will note any interesting aspect he finds in the farmer's current practice that can be added to what is already known about the crop production system and that might help refine future cycles of on-farm research.

V. Conclusion

The practical aspects of conducting on-farm trials for optimizing potato productivity analyzed here do not cover all problems the researcher will encounter. They constitute the most salient outcomes of our experience in on-farm research with potatoes and will certainly not provide answers to location or technology-specific problems. These location or technology specific problems must be solved "on the spot" by those conducting the research. Finding these solutions will be relatively easy if the search is inspired by the principle that the trials are focused on testing the relevance of an alternative technology to the improvement of the farmer's crop production system. All answers must aim to ensure this testing and give it the maximum degree of confidence possible.

VI. Example

1. Identification of the Alternative Technology and the Target Groups

A small valley situated within an irrigation development project area was selected for on-farm potato research. The potato program and the extension service of the Ministry of Agriculture were given the mandate to select and extend improved potato technology for the valley.

From a quick informal survey supplemented by interviews with extension agents and credit cooperative managers we have selected the following information because of its relevance to the example:

a. Potatoes are grown in the valley in two seasons:

- Planting March/ harvest in June, using imported certified seed.

- Planting early September/ harvest in December, using seed saved from the preceeding crop.

b. The two crops are irrigated (except the few weeks in March and November when rainfall is sufficient). The farmers have strong ties with the market (90% of the crop is sold in urban markets) and with the credit cooperative (75% of the farmers have used credit to purchase seed and fertilizers for the preceeding campaign).

c. Farmers interviewed indicated that yields of their second crop represent about 50% of the yields of the first crop. That same second crop was limited by scarcity of public irrigation water during September and by frost in late November-December.

d. The quality of seed used in the second crop was mentioned by farmers as a limiting factor but was not perceived as something they should (or could) improve.

e. Information from the irrigation development project showed that farmers owning more than 7 hectares are installing tube wells using facilities provided by the irrigation project. Small holders and tenants were very rarely interested in digging their own wells and were exclusively depending on the public water distribution system.

A survey of the crop in late September showed insufficient emergence in the majority of the fields and lack of moisture in the soil except for a few farmers equiped with tuber wells.

Based on this information the potato program suggested that a possible way to improve productivity in the second crop would be to replace the farmer's seed with that of the multiplication program grown in a different zone, harvested early May and could be made available to the farmers through the credit cooperative. Procedures to be followed would be those established for the imported seed (sold in February).

The alternative, consisting of adding to this variable (seed source) a second one (extra irrigation in September), was discarded first because it would complicate the trial and second because the public water distribution system had few chances of providing this extra amount of water.

Nevertheless and in order to tackle this water stress problem it was decided to work with two target groups:

a. Large farmers who owned tube wells, and,

b. Small farmers depending on the public water system only.

For these two groups it was decided to keep track of the irrigation dates especially during the 4 or 5 weeks following the planting.

2. Definition of the Trials and Basic Design

The trials were to compare performance of "improved seed" and the farmers seed. As a consequence the basic experimental design consisted of two adjacent plots:

plot A: Planted with improved seed.

plot F: Planted with the farmer's seed.

All operations from planting through crop care to harvest were carried out by the farmer following his normal practice.

3. Choice and Number of Collaborators

The on-farm research section could count on one ton of improved seed from the seed program. Taking in consideration the transport facilities, the distances to be covered and the amount of time that one potato specialist and one extension agent could devote to the trials, it was decided to divide the ton of seed into 10 lots of 100 kilos and to run 10 comparison trials: five with farmers owning a tube well and five with farmers depending on the public irrigation system.

Two groups of 10 farmers were selected at random from the lists of the irrigation project and a cooperation agreement was developed with the first 5 of each group who showed interest in the proposed trial.

4. The Cooperation Agreement

The agreement stipulates that the farmer will receive free of charge 100 kilos of seed and could keep the production. He committed himself to:

- Inform the extension agent of the planting date.
- Keep a record of the irrigation dates.
- Conduct all cultural practices on the two plots following his normal practices.
- Agree with the extension agent on the harvest date and permit data recording throughout the trial.

5. Size of the Plots and Their Position in the Farmer's Field

The size of the plots was dictated by the amount of "improved seed" available for each trial. For simplicity, it was decided that the plots were to be situated between two secondary irrigation ditches and consequently their length would be between 15 and 20 meters (distance utilized by the farmers) and their width would be chosen so that the total area of the plot would be 500 m^2 (estimated area to be covered by 100 Kg of seed). The choice of the field was to be made by the farmer.

6. Practical Procedures for the Installation of the Trial

The 100 kilos of improved seed should be counted at the experimental station. In the field, the technician would weigh and count 100 Kg of the farmer's seed. The distance (d) between two consecutive irrigation ditches was to be measured, thus leading to the determination of the width (w) of the plot $(w \frac{500}{d})$ The plots were marked, then the farmer was asked to plant the two plots using seed from each of the 100 kilo samples. When the farmer finished planting the plot, the remaining part of the 100 Kg sample was weighed and counted, thus allowing the scientist to record figures concerning the plant density and the seed rate used in each plot.

7. Follow-up of the Trial

After planting, the two plots were managed exactly the same way. The collaborator farmed the crop as normally. The scientist monitored the emergence of the two plots, their vigor and yield. These aspects were discussed with the collaborator. Besides regular visits at 3 weeks intervals, dates for supplementing visits were fixed by the necessities of recording data on emergence.

8. Proposed Evaluation of the Trial

The scientists proposed an alternative consisting of replacing the farmer's seed with that provided by the national program. Even if the two lots of seed belong to the same variety, they differ in several aspects:

- Different physiological age and phytosanitary status,

- Difference in size (thus the seed rates of the two plots will be different),

- Difference in price.

So, in reality, the trial was comparing two different "packages" dealing with a single production factor: seed.

The evaluation of the trial was based on:

- Rapidity and uniformity of emergence (which will probably allow a maturity before the frosts of December).

- Yields and their breakdown into the different marketing and pricing categories.

The "expression" of the package depended highly on the moisture status of the fields during the difficult month of September. This is why the trial was directed towards two distinct target groups and the evaluation done accordingly.

Finally, because of the scarcity of water in September and frosts in November-December, the potato crop in the area carries considerable risks. Because of this risk factor a technology that requires important increases in the production costs has very few chances of success. The evaluation must take this aspect into consideration.

9. Harvesting of the Trial

The harvest date was fixed by the farmer. Complete plots were harvested and their total yield determined. A sample of approximately 25 kilos of potatoes was used to determine the different grades of the harvest, according to farmer's criteria.

10. Agronomic Data Recording Sheet

This data recording sheet was designed in accordance with the planned evaluation of the trials. It is intentionally restricted to the data that will be used in the final analysis. The recording of the economic data is discussed in: D. Horton, "Gathering Economic Information for Evaluating On-Farm Potato Trials." Social Science Department Training Document 1982-4.

- Trial Number: - Locality:
- Tube well: Yes ___ No ___ - Collaborator:
- Planting date:
- Dates of the first four irrigations:
- Harvesting date:
- Frost occured on:
- Trial lay-out (on a separate sheet)

		Improved Seed	Farmer's Seed
Age of the seed			
Kg of seed used for 500 m^2			
Number of tubers used for 500 m^2			
Number of plants per plot emerged at	20 days		
	30 days		
	50 days		
Number of stems in 100 plants at	50 days		
Total yield (500 m^2 plot)			
% of first grade tubers			
% of 2nd grade tubers			
% of 3rd grade tubers			

The analysis and utilization of the results of this same series of trials is given in the last part of R. Cortbaoui "Evaluating and Utilizing Results of On-Farm Trials." Social Science Department Training Document 1982-5.