How to Conduct the Agricultural Field Experiments?

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Abstract: The experiment is usually associated with a scientific method for testing certain phenomena, which applies to science of agriculture as well. Since the agriculture is broad and therefore the experiments are diverse. Regarding to the agriculture is the work of Paul Richards that experimentation is at the heart of agricultural practice. The reason why agricultural experiments are something different for farmers and agriculturist is not their capacity to experiment as such but the embedding of experiments in a specific ecological, material and institutional environment. Since past the changes are examined in the organization of agricultural experiments and a gradual shift in the role of experiments in the connection between science and practice is very important with respect to the time and need of people. Initially, the link was considered to be established through various forms of experiments, rooted in an integrated social and technical understanding of subject but it turned into a connection primarily established through various forms of communication.

Key words: Agriculture, Experiments, Field, Kashmir, Methods, Phenomena.

INTRODUCTION
What is an agricultural experiment? Within the agricultural sciences the answer to this question will vary among disciplines. However its general aim I. e. testing certain agricultural phenomenon (Maat, 2011) remains same. The common features are a treatment, a hypothesized process or causal mechanisms to be tested. Living creatures or parts thereof are usually the object of an experiment. Today, each branch of the agricultural sciences will have its manual or guidelines for experimentation, depending on the object of the experiment, the place where the experiment is done, the treatment or process that is tested and the methods used. The connection between agricultural experiments and agricultural science seems obvious. However, at the beginning of the 20th century, agricultural scientists were very much in doubt about the validity of the commonly used experimental approach. In recent years, anthropologists like Richards (1989) and others claim that many of the basic agricultural activities carried out by farmers are experimental in nature as well.

Planning
In field experiments, one must consider lead time, objectives, benefits, alternatives, budgets, cooperators and work schedules. Start planning a half to a full year before the beginning of first field season. With adequate lead time, researcher can introduce the proposed project to the community well before the start-up date. This allows the people involved to evaluate the project. It also allows you to gauge interest in the project and identify potential cooperators based on expressed interest. Choose the best cooperators and incorporate their ideas into the project. Investigate and characterize potential field plot sites. Give any other agencies involved in the project the time they need to assess the study and allocate resources to it. Define the project's objectives early in the planning stage. The objectives should be clearly defined, obtainable with the existing resources and obtainable within the project's time frame. Provided the information is needed to the project.

Benefit to farmer society
The benefits to the farmer community involves the project's practical significance to local farmers, potential economic benefits and benefit from technology to group of people, the number of local operations that could be influenced by the study, the amount of interest expressed by local people, the current use of the technology in different areas. The alternative activities involves tour to another area for conducting a local field experiment? Its aim is to determine is the information that would come out of the project already be available. If the readily available information could be implemented without local tests or adaptation, you may not need to go to the time and expense of conducting an applied research experiment. A simple demonstration might be more appropriate.
Budget and cooperators

Make sure your planned budget does not exceed the available funds. Prepare realistic estimates of expenses. Be sure to consider all the costs involved like rental of land and equipment, materials, services, laboratory analyses, travel, manpower and tours and inflation. If it is a long-term project, contingencies of 10%, incidentals (e.g., long distance telephone charges, office supplies, film, camera, and audiovisual equipment), employee benefits (CPP, UIC, Worker's Compensation), insurance requirements for transporting equipment, highway permits, operator coverage, liability coverage, etc, awareness (signs, local newspaper advertisements and mailings) are necessary to meet. It is important to seek out potential cooperators months in advance. Contact more people than needed in case some are unable to participate. Involve potential cooperators in the planning stage. They need to know what will be expected of them so they can assess whether they can handle the project and if they wish to be involved.

Characteristics of a farmer cooperators:

It involves a genuine interest in the project topic, a commitment to seeing the project through to completion, respected in the farm community, enjoyment of receiving visitors to the farm and discussing the project, sufficiently outgoing to feel comfortable with the attention focused on the farm operation and the field experiment, the ability to cope with both known and unforeseen inconveniences, the ability to communicate and willingness to speak in front of a group, the time and equipment necessary to carry out the project and an unbiased record keeper. The cooperator's recorded observations are often valuable when it comes to explaining unexpected results.

Other possible cooperators are agribusiness personnel, university or government researchers and extension specialists, commodity marketing groups and producer groups. Once you have selected your cooperators, obtain written confirmation of their willingness to participate and sign a lease agreement if required. If possible, bring all cooperators together for a meeting before start up.

WORK SCHEDULE

<table>
<thead>
<tr>
<th>WORK SCHEDULE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step</strong></td>
</tr>
<tr>
<td>Planning</td>
</tr>
<tr>
<td>Collecting information</td>
</tr>
<tr>
<td>Public inputs</td>
</tr>
<tr>
<td>Locating site</td>
</tr>
<tr>
<td>Plot design</td>
</tr>
<tr>
<td>Plot layout</td>
</tr>
<tr>
<td>Sampling</td>
</tr>
<tr>
<td>Plot establishment</td>
</tr>
<tr>
<td>Signage</td>
</tr>
<tr>
<td>Plot maintenance</td>
</tr>
<tr>
<td>Data collection</td>
</tr>
<tr>
<td>Data analysis</td>
</tr>
<tr>
<td>Project evaluation</td>
</tr>
<tr>
<td>Report writing</td>
</tr>
<tr>
<td>Report presentation</td>
</tr>
</tbody>
</table>

Experimentation Design Applied

The overriding principle for experimental design is: **keep the design as simple as possible while satisfying the required level of scientific soundness**. You do not need a complex design with many experimental treatments, multi-factor interactions and difficult statistical analysis when a basic, simply designed experiment will produce the required information. Keep in mind that the purpose of an experiment is not only to answer a question, but also to provide some indication of the range of circumstances to which the answer applies.

Demonstration Strip Design

This is the simplest design type for a field trial. Basic farming practices or products are compared using demonstration strips on a farm field.
Examples of such practices that might be compared using this design are tillage type, crop varieties, herbicide applications or fertilizer methods. The emphasis is on visual impact, not on measured results that are critically compared. Usually the comparison is between two to four treatments, up to a maximum of 10. A treatment is a unique experimental practice or effect in the experiment. For example, in a trial comparing seven crop varieties, each variety strip is a treatment. In a trial comparing four levels of nitrogen fertilizer, each of the four levels is a treatment. In a demonstration strip design, each treatment is included only once.

Although this design is aimed at visual comparison, and in some cases a simplest measurement method is taken for one randomly located sample of a variable such as yield, from near the centre of each strip. The measured data from individual strips are compared to one another. In an attempt to account for natural variability within the field, several measurements may be taken at various locations within a strip. The measurements for each strip are averaged and these averages are used to compare the individual treatments.

Replicated Control Design

This is another very simple design type. It requires a minimum of land, labour and statistical analysis. The results are useful for comparison based on general trends but not absolute values.

As in the demonstration strip design, each treatment is included only once. However, in the replicated control design each experimental treatment is near to a control treatment. A control treatment is usually either a common practice or no practice. For instance, in a crop variety trial the usual variety grown in the area might be used as the control. In a fertilizer trial, the control treatment might be a strip with no fertilizer applied. To compare the results from different treatments, you first compare the results from each treatment with the results from the adjacent control.

Replicated Measurement t-Test Design

This type of design is well suited to field experiments when there is one treatment and a control condition, or two treatments. Suppose that you wish to find out if a new canola variety (A) is superior to an older, more commonly used variety (B). You want the study's results to apply across a region, so you recruit 20 farmers from across the region to participate in the study. Each farmer is prepared to plant either A or B in one field. The farms are then randomly assigned to A or B so that there are 10 farms in each group. A simple way to randomly assign would be to put the farm names on a list, then take a deck of cards and pick out 10 hearts and 10 spades. Shuffle the deck of 20 cards, and then turn them over one at a time as you go down the list of names. If a heart is turned over then the farm is assigned to variety A; if a spade is turned over then the farm is assigned to variety B.

Randomized Complete Block Design

The randomized complete block design (RCB), is widely used in field experimentation. It is an extension of the paired t-test. This design is appropriate when you are collecting quantitative data, such as yield, and you require a rigorous comparison between treatments. The two cornerstones of the RCB design are replication (i.e., repetition) and randomization. These allow you to accommodate any variability in the local environment and to determine the probability of the differences in results between treatments being real or simply due to chance.

During my post-graduation research programme I used the RCB design in the filed experiments while evaluating the relative resistance of 12 genotypes of brinjal in Kashmir. I take three rows each with 12 subplots, assigned the 12 genotypes randomly. All the requirements for the design were met before the experiment. Each treatment was randomly replicated three times in the three rows. The experimental field was plan, with no difference in fertility gradient. The previous cropping history was also taken into consideration.

Replicate each treatment a minimum of three times. Four replicates are better than three, and five better than four, but the statistical advantage gained is successively smaller with each added replicate. Replication locations must be selected to represent the range of generalization. Each treatment must be included once in each block of replicates. The treatment locations must be randomly assigned to plots within the block. The purpose of randomizing the locations is to avoid biasing the results and maximize the precision.

If field plots are your basic experimental unit, the individual plots should be three to five times long as wide and should be sized to comfortably handle one or two passes of the field equipment being used. Proper plot location is important to reduce bias in the results. If the plots are on sloping land, run the long axis of the plots up and down the slope. With this layout, each plot will contain a portion of each slope position. (If the long axis of the plots runs across the slope, the lower slope
treatment will be in a different environment than the upper slope treatment.) Similarly, if soil characteristics gradually change across the study site, run the long axis of the plots parallel to the gradient of soil variability.

**Tests for RCB data**

Two standard statistical tests are used together in analysis of data from an RCB design. An F-test, commonly called Analysis of Variance (ANOVA), is used to determine if there are significant differences between some of the treatments. If the F-test shows that significant treatment differences do exist, then a means comparison test, such as the Dunn's test or Duncan's Multiple Range (DMR) test, is used to determine which treatment means (i.e., treatment averages) are actually different from one another.

**Advantages**

There are two advantages to using an RCB design over the replicated measurement t-test design described above. One is the ability to compare numerous treatments using one analysis (the F-test). The second is the ability to separate out differences between replicates caused by environmental gradients (e.g., changing topsoil depth).

**Split Plot Design**

This design allows the testing of two factors in combination. One factor (the main effect) serves as a replication for the second factor (the split effect). There are many split plot design options, but the basic principle involves assigning one set of treatments to the main plots that are arranged in randomized complete blocks. The second set of treatments are assigned to subplots within each main plot. The statistical analysis is similar to that used with the RCB design. That is, an ANOVA set up for a split plot is followed by a means comparison test such as the Dunn's test or DMR test.

During my doctorial research I used the split plot design as given below.

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<tr>
<th>Design of the experiment</th>
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<tbody>
<tr>
<td>Locations</td>
<td>03</td>
</tr>
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<td>Ultimate sample size</td>
<td>3trees/species/experimental location</td>
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<tr>
<td>Replications</td>
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</tr>
<tr>
<td>Treatment</td>
<td>Pollinator</td>
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The sample size (pollinators) within the each three plots of the one experimental location varies, therefore each plot were sampled independently. And the stratification were done homogenously before sampling. The plots of every experimental location (strata) were mutually exclusive. The strata are collectively exhaustive, and no population element were excluded. The Stratified Random Sampling were applied within each strata. Further each population per strata were its representative. And the arithmetic mean of the population were done to determine the variability/exp. Location (strata).

**Factorial Design**

In a factorial design, you can simultaneously observe the effect of two or more factors. That is, the design provides information on the average effect of the individual factors as well as the interaction between these two factors. For example, if nitrogen and sulphur fertilizers are the two factors being studied, you could determine if there was an additional effect of nitrogen and sulphur applied together that would not be accounted for by nitrogen or sulphur individually. This design type also allows a wider application of the conclusions reached on the effect of each factor because each factor is tested over a wide range of conditions of other pertinent factors. The statistical analysis used is ANOVA followed by a DMR test.

**EXPERIMENTATION SITE LOCATION**

The location of a project site often makes or breaks a project. Proper location can reduce the effect of natural variability on project results and optimize plot accessibility and visibility. When selecting your site location:

- soil variability
- site topography
- site drainage
- site access
- site visibility

**Soil variability**

Soils are inherently non-uniform. Characteristics that are variable or cause variability include:

- texture
- permeability
- variability of subsoils
- salinity
- chemical and fertilizer application history
• dead furrows, turn-rows, and headlands

Former fence lines and field boundaries
Select a uniform and representative portion of the field for your project site. If variability cannot be avoided, minimize its effects by:
• Using long and narrow plots running in the direction of the greatest soil variation. This encompasses as much of the variability in the field as possible without exposing the whole field to the treatment.
• Determining the cropping and management history of the field.

Collecting samples for fertility and salinity testing
Site topography and drainage
The site characteristics should be as representative of your area as possible. Keep away from headlands and field entrances. The site should be well drained and should not have any watercourses running through the plots. Try to select simple slopes. Locate the site in a mid-slope position to avoid the effects of soil erosion and deposition. If more than one site is being selected and you want to compare results, ensure that the slope aspect (i.e., the direction in which the slope faces) is the same at all sites.

Site access
All types of vehicles, from tour buses to tractors, need access to the site. Access should not be limited by poor weather. Farmers should be able to stop at any time and walk to the site. Establish and maintain walkways to and around the site. Spring-seeded winter wheat is often used for walkways as it has a low growth habit.

Site visibility
Locate the site so it can be seen from main roads. If it can be seen from a kilometer or more away, there is more time for the driver's curiosity to build and more time to plan a stop or slow down. Projects located near stop signs benefit from the fact that a farmer driving by must come to a stop there.

PROJECT IMPLEMENTATION
Follow your planned work schedule as closely as possible. If you must change the schedule, inform everyone involved in the project. Consider the farmer cooperator's routine field operations when laying out plots. Strip plots should be parallel to the field edge and far enough from the field edge to allow passage of the farmer's equipment. The width of the farmer's sprayer is often the most important consideration. If the farmer will not be spraying the plots or if the plots are to be sprayed with a chemical other than the ones used on the rest of the field, then the distance between the plots and the field edge should be some multiple of the sprayer width. The width of seeding and harvesting equipment should also be considered. Measure the location with a surveyor's chain or a measuring wheel, and record these measurements on the permanent plot map. Install flags to guide the tractor operator when the field work is done.

Signs reinforce the project's demonstration value. A standard sheet of plywood is a good size for a main sign. Accessory signs, to explain treatments, cooperators, history and so on, can be smaller. Individual plot signs should be used, especially if there are more than two plots. Keep plot signs brief and to the point. Words like "alfalfa" are often not needed on plot signs; a variety name such as "Beaver" is probably sufficient, especially once the crop is up. Lettering on all signs should be thick and as large as possible. Detailed plot information sheets can be kept in a mailbox at the site or mounted on a waterproof board.

Make sure signage and plot stakes do not interfere with field operations. For example, if the cooperator will be spraying a field plot, make sure the stakes are short enough to be cleared by the spray boom. Keep the site neat and tidy. Check it frequently for fallen signs, weather damage, etc. Ensure walkways are mowed and weeds controlled. Routine visits to the site should include time to share ideas with the cooperator to coordinate activities.

DATA COLLECTION
Field experiments should be monitored regularly. The frequency of monitoring will depend on the observations required to meet the project's objectives. Different types of experiments require different types of measurements. For example, in field crop studies, crop yields would be appropriate measurements. For weed control experiments, measurements could be made of weed populations before and after the experimental treatments. In livestock projects, measurements could be live weights of the individual animals at pre-determined times.

Crop yields can be measured using a weigh wagon (harvesting the plot strips with a combine) or from square meter samples. Harvesting strip plots with combines and weigh wagons is a quick and easy way to measure crop yields. Several points should be kept in mind to ensure reliable and consistent results with this method:
• Keep in touch with the cooperators as harvest approaches so you can help them swath the plots correctly and be there when they do the threshing.
• Explain to the cooperators about the need to take a full width swath out of the center of each treatment plot.
• Take samples at least one meter from the end of the plot to avoid edge effects that could confound results.
• Install marker flags to guide the operator down each strip.

Crop residue levels may be measured using the knotted rope method or square meter weights (for heavy residue). Soil moisture measurements may be carried out in the fall or before planting or both. Gravimetric soil moisture sampling needs a core sampler, weigh scale, containers and oven. Decide on depth increments. For example, use increments of 0-15, 15-30, 30-45, 45-60, 60-90 and 90-120 cm for measuring moisture within the typical rooting zone (1.2 m).

Weather information, especially temperature and rainfall, should be recorded during the growing season. Rainfall should be measured at the site. Temperatures measured at a nearby weather station may be adequate if the station is located near the experiment. Wind speed and direction should be recorded on days when chemicals are applied. Photographs taken during the course of the growing season provide excellent records of visual responses. They are also very useful if you are asked to give a presentation about the project at an extension meeting or to prepare an article for a local newspaper or bulletin.

TECHNOLOGY TRANSFER
To maximize project benefits, farmers must be made aware of the project. Begin publicizing your project early in the planning stage. This can start when you are seeking cooperators for the study. The search for cooperators involves making as many people as possible aware of the proposed project. Announcements at farm meetings, in newsletters and in the local news media can reach a large number of producers in a short time.

Once the project is established, install appropriate signs. Provide more detailed information on a plot information sheet. Use half the page (or one side of a two-sided page) to describe the study objectives and plot plan, and the other half for additional information. These sheets should always be available at the site, either in a mailbox or mounted on a waterproof board, so casual visitors to the site can read them. Update the sheets as the season progresses with such information as seeding date, chemical applications, varieties, etc.

Tours and field days are usually the most effective way of informing farmers about the project's results. Project personnel should attend tours and field days to present their research data. A social activity, such as a lunch or barbecue, held with the tour provides an opportunity for participants to informally discuss the project among themselves and with site operators. Social activities can also increase tour attendance. The timing of tours is critical. Try to time them so there are some visual results for tour participants to observe. Avoid scheduling tours during busy field work times (e.g., seeding, spraying, haying and harvest), and try to avoid conflicts with other local and provincial tours or field days.

Send written invitations of tours and field days to the local news media. Project personnel and cooperators should make themselves available to the media for interviews. It is important that the contributions of all cooperators be formally recognized at every opportunity. Ways to recognize sponsors and cooperators include:

• Identifying the inputs of cooperators in budgets.
• Identifying all funding agencies and sponsors on signs and publications.
• Placing sponsor logos on all project-related information (e.g., newsletter articles, meeting programs, signs).
• Formally introducing cooperators, sponsors and industry representatives at all official meetings.

EVALUATION AND EFFECTIVENESS
Evaluating the amount of interest and learning derived from your project will help you to plan and improve future projects. Project evaluation can be formal, for example, using an evaluation form with specific questions, or it can be informal, such as comments from coffee shop conversations.

1. Include the site on a tour in your area. Record how many people attend the tour? Talk to participants to determine if some of the attendance can be directly attributed to your project. At the last stop, hand out an evaluation form to find out if tour participants are likely to change management practices as a result of seeing your field experiment.
2. Use a mailbox at the site to hold project information sheets. Count the number of sheets placed in the box initially and the number at the end of the season. Alternatively, count the number remaining at the end of each month. Was there a month of peak interest? What factors might have produced this peak (e.g., the peak visual impact of the plots, peak media publicity about the project)?

3. At a large winter extension meeting have an evaluation form available for the research and awareness activities that you or your agency conducted during the previous year. This allows you to evaluate several projects at once and ask for suggestions for future projects.

4. Gauge community response. Was there talk about the new technology at the coffee shop, wedding dance, pot-luck supper? Did increased awareness of the technology arise as a result of visits to your project site? Were complaints or criticisms levelled at the study? How might future projects be improved to avoid these criticisms?

REPORTING
Applied research and demonstration projects require formal reporting either at project completion or at intervals during the project. Report timing and format are usually specified by the agency funding the project. Most report formats include the following information:

- **Abstract or Summary** - Briefly summarize the project, usually in half a page or less. Highlight results or progress to date, including any significant deviations from the original objectives.
- **Background and Objectives** - Explain the need for the project and state its purpose.
- **Methods** - Outline the project design and any significant details of the procedures used. Provide enough detail so others could repeat your experiment if desired.
- **Results** - For final reports, describe the project results. For interim reports, summarize the work completed to date. Be objective when reporting your results; don't try to make them fit a preconceived conclusion. Measurements (e.g., yields, weight gains, weed populations, etc.) should be included. Results may be presented in tables or graphs. An example of a table is shown below.

THE FUTURE OF AGRICULTURAL EXPERIMENTS

The development of various forms of scientific experiments for crop improvement has led to considerable advancement in finding the optimal agricultural conditions that, in combination with modification of the genetic composition of crop varieties, has resulted in a considerable yield increase. However, under most farming conditions, in particular in developing countries, such optimal conditions are difficult to attain. The difference between potential yield and actual yields attained in the field, known as the yield gap, has become a growing concern for international agricultural development agencies. The changes in how the connection between scientific experiments and the (experimental) activities of farmers has developed over the years have resulted in an ‘experimental gap’. Although many factors reduce yields in farmers’ fields and vary from place to place, dealing with the experimental gap is an effort to be made in order to effectively tackle the yield gap. Brief explorations of two present-day examples with respect to rice farming may clarify how narrowing the experimental gap might be achieved. The first example is the scientific debate over the System of Rice Intensification. The second example brings us back to the work of Paul Richards on rice farming in West Africa.

Emerging from the work of the Jesuit priest de Laulanie, the System of Rice Intensification (SRI) has developed into a widely promoted method for rice cultivation (Glover, 2011). Questioned by various rice scientists in the international research network, a controversy emerged that appeared in various agronomic journals, which was serious enough to get coverage on the editorial pages of Nature (Surridge, 2004). Although the debate focused mainly on the yield potential of SRI, an issue that was stressed in particular in contributions from the soil scientist Willem Stoop, was the nature of experimental work required to adequately test the various components of SRI. Given that various forms of SRI are applied by farmers under different conditions, considerable experimental work is needed, ranging from relative simple on-farm experiments to more complicated multi-factorial analysis (Stoop and Hart, 2005) and (Stoop et al, 2009). Having worked in international research centers for many years, Stoop observes that the experimental work at these centers is too remote from the type of field experiments needed to test SRI in an adequate manner. Given that SRI is promoted widely in various countries by government and non-government organizations without any form of scientific test. In fact, the practices promoted by Holle, i.e., reduction of seed
and wider plant spacing, are among the key principles of SRI.

Where the SRI case illustrates some of the limits of the national and international research institutes in connecting to the field level, the second example illustrates the capacity of farmer-based experimentation. Through collection of rice varieties at several locations in West Africa, a team of African and European researchers demonstrated the existence of interspecific hybrids (between *Oryza glabberima* and *O. sativa*) in farmers’ fields. Resulting from intercropping of the two species in the same or nearby fields (Nuijten et al., 2009). The farmer hybrids were used independently and long before another interspecific hybrid, called NERICA (New Rice for Africa), was introduced to the region in 2002 by the African Rice Centre (WARDA). NERICA was exalted by scientists and policy makers as a showcase of international agricultural research. Researchers knew about the existence of interspecific hybrids in farmer's fields. However, no initiative was taken by the African Rice Centre to connect to and learn from rice farming practice with respect to interspecific hybrids, shows that the current research system is predominantly focused on scientific solutions, excluding available information obtained from field studies.

What, then, is needed to close or at least narrow the gap between scientific experiments and the experimental activities of farmers? As pointed out above, the notion of farming as a performative, experimental activity as worked out by Richards suggests that there is no fundamental obstacle to overcome for creating such a connection. From his involvement in several shared experiments between farmers and scientists, Richards recently elaborated a suggestion for a different organizational principle of agricultural experiments (Richards et al, 2009). Taking up a distinction drawn in artificial intelligence research, he points out that most conventional research is organized as supervised learning, being the instruction of fixed solutions within a given set of conditions. By contrast, unsupervised learning works on the basis of feedback mechanisms that, within a network, lead to solutions that emerge as the combined outcome of the various feedback mechanisms. Comparing Richards’ arguments with the history of agricultural experimentation, the unsupervised learning structures provide greater space for farmer experimentation and do not require an extensive experimental bureaucracy to organize a pre-structured connection between various forms of experimentation. This also implies a different role for extension and agricultural advisors. Rather than setting up staged demonstrations and make farmers behave as a compliant audience for the miracles of modern science, advisors have to rediscover their agronomic roots, assess different forms of information and collectively design creative experiments that serve a mixed audience of farmers and scientists. Moreover, integration of professional agriculturists and social-economic factors requires experimental forms that allow for integration of both types of data.

**Conclusions** - State whether or not the project's objectives were met. State any factors that contributed to the project outcome. Describe any formal or informal evaluations of the awareness phase of the project, assess this phase and summarize ideas for improving future projects.

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**Contradiction of authors:** No contradictions of authors at all

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