EVALUATION OF ON-FARM RESEARCH TRIALS FOR DERIVING RECOMMENDATIONS

By

P. ANANDAJAYASEKERAM
A.F.E. PALMER

CIMMYT, P.O. BOX 25171, NAIROBI, KENYA

Presented at the Tanzania National Maize Workshop, Arusha June 6-10, 1988

EVALUATION OF ON-FARM RESEARCH TRIALS FOR DERIVING RECOMMENDATIONS

1. Introduction:

The ultimate objective of the agricultural research process is to generate recommendations which could be adopted by the farmers under consideration to improve the production and productivity of their limited resources. A recommendation is a technical information that farmers can use. A good recommendation can be defined as the choice which farmers would make, given their current resources, if they had all the information available to the researchers. It is widely accepted that farmers, in general, are reasonably good decision makers i.e. rational in their decision making and rarely accept recommended technologies/technological components unless it is in their interest to do so. In general the accepted technology should:

- lead to increased overall production of the system
- lead to increased income at reasonable level of risks and
- be reasonably compatible with current farming systems practices.

It is also well documented that, as a rule, farmers rarely make large changes in their farming system at any given time. Rather they tend to change their practices in a gradual manner one or two practices at a time, in a stepwise fashion. This is called the "stepwise adoption" of technology. Therefore, in order to make good recommendations for farmers, researchers must be able to evaluate alternative technologies from the farmers' point of view.

Assessment of the experiment/experimental data is one of the critical steps in the recommendation generation process. If the recommendations are to be accepted by the farmers, the trial should be evaluated in the manner a farmer would use to make the decision. The criteria used in the assessment must be consistent with that of the target group of farmers whose problems are under investigation. Wrong criteria will often lead to wrong conclusions, thus minimizing the likelihood of acceptance of the recommendation by the farmers. This paper will not discuss the actual techniques and procedures used in the evaluation process but will highlight the various aspects that should be taken into consideration before a recommendation is made.

2. Evaluation:

Evaluation assesses the impact of the technology on the individual farm/system under consideration. In actual fact, evaluation begins even before the trial is laid out in the field; then the process continues while the trial is in the field and ends with the final evaluation once the trial is completed. Thus we can divide the evaluation process into 3 steps.

a) Ex-ante evaluation
b) On-going evaluation
c) Ex-post evaluation

2.1 Ex-ante Evaluation

The ex-ante evaluation is also known as screening. Screening is one of the important elements in the planning process. For a well defined problem, whose causes are fairly well understood, one can list all possible solutions. In order to avoid wasting limited research resources, it is very important to make sure that only the most attractive and seemingly feasible solutions to the most important problems should be included in experimentation.

Each possible/potential solution should be checked for technical feasibility expected profitability, expected risk, relative research cost and farming system compatibility. (This aspect of system compatibility is discussed in detail later on in the paper). This is not a very rigorous evaluation, but relies on the researchers' subjective judgement based on the available information. It is important to remember the following points for screening purposes:

- there are no fixed rules
- the researchers' judgement is the best guide
- it is a very rough evaluation.

A series of questions are asked about each of the potential solutions identified.

1. Is the technology consistent with farmers' consumption goals?

2. Is the technology consistent with the farmers' priority objectives?

3. Does the technology produce higher yields under farmer circumstances, and is it workable under farmer circumstances (time and management)?

4. What is the yield required to cover the increased cost of the technology/treatment?

5. Is it compatible with farmers' available resources?

6. Does the technology require changes in the level or timing of resource use which conflicts with farmers' capacity and or with other production activities of the farmers?

7. What is the likelihood of getting higher yields?

8. Will the potential solution get the infrastructural and institutional service support required? If they are not available how difficult are these to get?

If one gets a favourable response to these questions then this technical option is considered to be a feasible option and considered further in the planning process. One should note that there is an explicit acknowledgement that 'judgement' or qualitative assessment cannot be avoided at this stage. This is only a preliminary assessment and one has to come back to a rigorous assessment of the same questions once the experiment is completed.

2.2 On-going evaluation

On-going evaluation refers to the periodic evaluation or assessment during the implementation of the experiment. On-going evaluation could be done by having repeated meetings with farmers, extension workers and even fellow research workers at the site. This type of evaluation may not necessarily be quantitative. The management difficulties associated with the technology could be easily identified through on-going evaluation. Farmers could provide ideas about required treatment modifications.

2.3 Ex-post evaluation

This is the traditional type of evaluation carried out after the completion of the experiment. Before we proceed any further it is important to make sure that the quality and quantity of the data is sufficient to inspire confidence that the results will be repeated.

The first step in the ex-post evaluation process is to scrutinize the trial management and data to establish the following:

1. The experiments were planted at locations that are representative of farmers' conditions.

2. Based on the trial performance, that there is no need to regroup the data set i.e. all locations belong to the same target group and can therefore be analysed together.

3. There are no experimental management errors.

4. That the non-experimental variables at each location are carefully monitored and recorded and based on this there is no need to make adjustments.

2.3.1 Statistical analysis

Once the data scrutiny is completed and the researcher is confident about the quality and repeatability of the data, then the next step is to carry out the statistical analysis. Traditionally, agronomic trials are evaluated by biological scientists using statistical techniques and the dominant evaluation criterion used is the output per unit area. Depending on the design of the trial various techniques are used and the valid test is the level of statistical significance.

This test alone has many limitations in deriving recommendations for a target group of farmers:

1. The agronomic physical input-output data only establish the technical relationship which could be used to determine the technical optimum. It should be complemented with market information in order to establish the economic optimum i.e. prices of inputs and outputs.

2. The evaluation criteria that the farmers would use are varied, and location specific, depending greatly on the degree of market orientation. The relevant criteria for the target group must be identified and used in the design and interpretation of the experiment.

3. Farm level decisions are made and actions are taken in an attempt to reach goals in a world of uncertainty and scarce resources.

It is important to recognize that a host of variables influence the farmers' choice of a technology. These may be physical, biological or socio-economic. Very often the socio-economic factors, such as lack of market for the product, shortage of labour, conflict with food priority etc. dominate these choices. For instance:

- varietal means may not be significantly different but the farmer may prefer one over the other based on differences in palatability, storability, cooking quality, cooking time etc.

- The technology/recommendation may not increase the yield but may reduce the labour requirement at a critical period.

- The yield may be lower than the current variety but may offer the possibility of introducing a second crop, thus increasing the total production of the system.

- The farmers may choose a variety with multiple uses e.g. sweet potato tubers and fodder, cowpea varieties both for grains and leaves, etc.

The argument does not in any way underestimate the importance of statistical analysis. It is important however, to keep in mind that the greatest value of the statistical analysis is not in deriving recommendations but in determining what is happening biologically in the experiment. The statistical analysis, in fact, guide the subsequent economic analysis. If there are no real differences in yields, then the total variable costs of each treatment should be compared, and the treatment with the lowest costs chosen. If, on the other hand, the statistical analysis confirms that the differences observed among treatments are real, then a marginal analysis should be carried out and the economic analysis should be given sufficient emphasis.

Therefore, statistical analysis alone is not sufficient to make definite recommendations. Hence, it is necessary for the biological scientists to subject their trials to economic analysis. This calls for the agronomists and economists to jointly evaluate the trials to establish both biological and economic viability. The usefulness of many biological research trials can be greatly increased if simple economic analysis is applied to the results.

2.3.2 Economic evaluation

The economic evaluation of a trial can be considered at two levels: at micro level (looking at the impact on the individual level) and at macro level (looking at the effects at the aggregate level). Needless to say that our discussion will deal with the micro level economic analysis of the agronomic data. Though there are many sophisticated techniques available to perform economic analysis, a simple tool such as a partial budget is adequate to carry out meaningful analysis to derive recommendations. A partial budget provides a useful starting point and is a formal way of comparing costs and benefits of a treatment or a production process. In addition it can be used to figure out the rate of returns on limiting resources, can handle response analysis and can also handle aspects of risk in a crude way.

Though the technique is very simple, very often the budgets are constructed improperly. There are various reasons for this:

1. Incorrect prices of inputs and outputs are used.

2. Not all or the wrong levels of outputs are included in the analysis.

3. The wrong inputs at the wrong levels are included while others are left out.

4. The effective limiting resources in the production process are not correctly identified.

Therefore it is important to bear in mind that:

a) all sources of benefits and costs to farmers should be brought into the analysis and

b) the realism of the costs, prices and yields are as important as the type of analysis chosen.

The real costs of input and outputs to a farmer will usually differ from reported market prices. A typical limitation of many budget analysis is that they use market prices and not the actual price received by the farmer. Similarly, the yield that benefits the farmers is frequently less than the reported yield by the researcher depending on the location of the trial, type of management etc. The net effect of these biases is to overestimate the gross benefit and underestimate the variable costs. Not surprisingly, the farmer assessment of a recommendation/technology may be different from the researchers assessment of the same practice.

Once again the economic evaluation looks at the following aspects simultaneously:

a) Profitability:

Here it is important to make sure that the benefits are adequate enough to cover the direct costs and offer some additional returns on the invested resources to make it attractive for the farmers to adopt the recommendation/ technology. Depending on the limiting constraint identified in the production system under consideration, the marginal rate of return per unit of cash invested should be greater than the minimum acceptable rate of return (direct cost, risk premium, and incentive for good management) for the farmer; or the marginal rate of return per unit of labour is greater than the current return or best alternative returns the labour can have under the current circumstances of the farmers. It is also important to remember that a partial budget analysis will not give the net effect of a technology/production process. It only gives us the change in net benefit. Therefore we cannot talk about the profitability of the enterprise or the farm. In order to do this one has to construct an enterprise budget or a whole farm budget.

b) Risk

It is a known fact that the farmers attempt to protect themselves against the risks of loss in benefits and often tend to avoid choices which would increase the element of risk, even though these choices may on the average yield them positive benefits. Yield stability is much more critical for many small farmers. One way of assuming this is to compare the performance of the worst 25% of the treatments for each location with the current farmers' practice (Minimum Returns Analysis). If the average net benefits are greater than the farmers' current practice this indicates that even the worst cases of the technology does better than the farmers' practice. The magnitude of the difference between the worst treatments (25%) and the current farmer practice is critical in making choices. If the differences in performance are not very obvious, then the farmer may be able to assist in the final evaluation. The stability of the recommendation against changing prices could be tested through sensitivity analysis.

c) System compatibility

If the technology is considered to be profitable and does not increase the risk substantially then the effect of the technology/recommendation is assessed on each of several aspects of the farming system including:

- land use and cropping calender
- cash and credit resources
- labour resources
- draft power resources
- input availability
- farmer food requirement and preference
- livestock feed requirement
- social acceptability
- implications to marketing
- interaction with the other components in the system etc.

Though the listing looks laborious, once the researcher has a clear understanding of the production system with which he is working, then the assessment of the recommendation for system compatibility is a very quick and easy to perform. This aspect of system compatibility should be looked at very carefully if we are very close to making a recommendation.

2.3.3 Farmer Assessment

Economic analysis is a further step in selecting a new technology or a recommendation. In conducting economic evaluation researchers assume that they are familiar with the important costs and returns associated with the new technology and the decision criteria used are similar to those used by the farmers. This assumption may not be true. One further step is 'farmer assessment' of the new technology.

In farmer assessment, those farmers with sufficient knowledge about the technology (collaborators, visitors during demonstrations) explain the advantages and disadvantages of the technology, and describe why they decided in favour or against it. Farmer assessment could be informal (repeated meeting at the sites) or formal (surveys). Selection of farmers and selection of appropriate methods are equally important in farmer assessment.

3. Experimental evaluation and the type of on-farm experiment

It is important to keep in mind that experiments are carried out with different objectives in mind. The purpose of the experiment will dictate the criteria used in the evaluation.

a) Some experiments are carried out to identify the critical factors affecting production. These are the exploratory type of trials. The treatments in this type of trials are chosen to identify the effects of the suspected factors in order to continue with the trial program and thus do not always represent economically viable solutions to the particular problem. These experiments often provide guidelines for further research before recommendations are made. Based on the results the treatments could be changed, (rate, frequency etc) or the factor may qualify for a level/determinative type of trial. In exploratory type of experiments statistical assessment is very crucial and the aim is not developing recommendation. Both economic evaluation and farmer assessment play a less significant role in the evaluation process.

b) Experiments may be conducted to establish the causal factor(s) of a problem if that is not clearly defined. Here again the information obtained is used for further research and statistical analysis plays a very critical role.

c) Sometimes experiments are carried out to provide information to policy makers to make changes in the existing policies or to formulate new policies with respect to input supply, credit regulations etc. Here both statistical and economic analysis play equal roles.

d) Sometimes experiments are planted to use the information for

- making recommendations. Here the problem is well defined, causes and possible system interactions are well established and the experiment is carried out with a view to making recommendations. Here the analysis should be very rigorous and should subject the technology to statistical, economic and farmer assessment. System compatibility is much more critical in deriving recommendations. Thus depending on the objective of the trial the relative importance of these different assessments does vary. This should be given due consideration in experimental evaluation.

4. Special consideration in Experimental Evaluation

In the previous sections, the paper generally dealt with the different evaluation measures that one could use in evaluation of experiments to develop recommendations. However, it is important to note that the following type of trials need some special consideration in performing evaluation:

a) Intercropping/multiple cropping experiments
b) Factorial trials
c) Trials involving crop sequence, fallowing, and when benefits are distributed over a period of time e.g. liming, green manuring, etc.

4.1 Intercropping/multiple cropping trials

Economics and agronomy are inseparable in multiple or intercropping systems. There are three bio-economic relationships which form the basis for the design and analysis of multiple/intercropping systems.

1. Relationship between input and output
2. Interaction of two or more inputs to produce a given product mix and
3. Effects between two or more crops.

Traditionally, each product in the mix is treated separately and the statistical analysis is performed independently. Another approach taken is to compute the Land Equivalent Ratio (LER) where the products are combined in a particular manner to generate a coefficient to determine the efficiency with which land is being utilized under the given combination. In an intercropping trial:

- there is more than one harvested yield per plot
- the yields are almost always negatively correlated
- the value and quality of the output of one species is likely to be different from the quality and value of another species in the trial

In order to combine the outputs, so as to perform a combined analysis, the yield of each species must be converted to common basis. The unit for measuring production from a multiple/intercropping system must satisfy several criteria for it to be useful in the evaluation. Peter Hildebrand identifies at least 5 such criteria (2).

- it must be common to all products

- it should be relatively easy to measure

- it must be capable of reflecting quality differences between products

- it must provide a means to compare different cropping systems

- It must be meaningful to a farmer in such a way that it helps him to allocate his resources between competing uses on the farm.

The only criterion available which meets all five conditions is the market value of the product. There is consensus among agronomists and biometricians that statistical analysis of multiple/intercropping trials can be performed with this combined monetary value. However, if the relative prices change, then the analysis should be repeated with the new prices.

Performing statistical analysis using combined monetary value is in no way a substitute for economic evaluation. Once the statistical assessment is completed then the economic evaluation could be performed as for any other trials. However, if it is an intercropping trial e.g. maize and beans then the partial budget will have two average yields, two adjusted yields and two gross field benefits.

4.2 Factorial Trials

In factorial type of trials the major objective is to study the main effects of the individual factors and the first order interaction of these factors. The results of these trials are used to plan further research. In these cases, the economic analysis is focused on factors and not on individual treatments. Based on the results of the statistical analysis, and the observed interactions budgets are constructed for possible combinations and evaluation is done in the same way. If there are no interactions, then factors are looked at individually. If there are no significant differences in the yield for any factor then the least cost level of the factor is chosen.

4.3 Long Term Trials

Here the benefits of the treatments are distributed over a period normally covering more than one crop cycle. Under such circumstances the costs and benefits should be reduced to one period/season and evaluation performed. The procedure here may be little more complicated than the other trials.

5. Conclusion

Before an innovation can be judged as superior to existing technology or before a recommendation is made, its relevance should be jointly evaluated by researchers, farmers and the extension staff. It should be evaluated using three criteria simultaneously.

1. An analysis of the factors influencing the yield

   - statistical analysis
   - agronomic assessment

2. An economic assessment of the technology under consideration

3. The farmer's impression of the proposed technology.

Both on-going evaluation and ex-post evaluation are equally important in experimental assessment. The type of evaluation to be performed should be decided at the time of planning. At planning stage the following should be decided:

- who is the client for the results i.e. establish the purpose of the trial

- establish what criteria to use in evaluation

- the appropriate statistical and economic analysis to be used

- the type of data required to perform the analysis and the method of collecting such information.

Due consideration must be given in planning the experiment to collect the relevant information so that one can evaluate the experiment/technology thoroughly before recommendations are made. Make sure that you combine the formal evaluation with the informal assessment of the farmers before decisions are made.

Acknowledgement

The authors wish to thank Dr. W. Mwangi for his valuable comments on an earlier version of this paper. However, the authors are solely responsible for omissions and errors if any.

Selected References

1. CIMMYT, 1988.
From Agronomic Data to Farmer Recommendation: An Economics Training Manual, completely revised edition. Mexico, D.F.

2. Hildebrand P.E. (1977).
Multiple Cropping Systems are Dollars and 'Sense' Agronomy. pp 347-372. IN L.I. Papendick (ed.) Multiple Cropping. ASA Special Publication No. 27. American Society of Agron., Madison, W.I.

3. Ransom J.K. (1988).
A Simple Method for Analysing Intercropping Trials. A paper presented at the Tanzania Maize Workshop, Arusha, June 6-11, 1988.