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How big should on-farm trials be and how many plots should be measured?

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· Introduction

Traditional agricultural research has been the preserve of scientists who have acted on behalf of farmers. This research resulted in many measurements of great precision which can be analysed according to standard procedures. However, no matter how good the science might be or how persistent the extension efforts, it has been found repeatedly that technological advances will not be adopted unless they are acceptable to farmers. For example, in Jamaica the recommended practices for the control of sweet potato weevil have been known, and extended, for 100 years but never adopted by farmers because of their labour constraints.

The participatory approach to agricultural research and development attempts to overcome this problem and learn from the farmer. Since agricultural researchers have left the confines of research stations to pursue their investigations alongside farmers, new research techniques have had to be developed, and others modified, in order to adapt to changes in location as well as to a more multi-disciplinary approach. This article discusses some conflicts which arise when agricultural research is conducted on farmers' fields. Such research often has multiple objectives which can be incompatible.

On the one hand, researchers wish to gain reliable, objective and quantitative information on the performance of a technology, while at the same time, obtain the farmer's opinion of it. Further, economists may wish to assess the potential economic impact which the technology may have and the sociologist the social aspects (e.g. displacement of labour).

On-farm trials are often conducted where only limited areas of land are available and where there is the likelihood of large differences in production from different sections of the field. The usual approach to research comparing different technologies would require many harvest areas to be planted to get precise (if inaccurate) estimates of yield. Large harvest areas would be required to get accurate yields for economic analyses and assessments of inputs (particularly labour).

Yield measurement

Current literature indicates that to assess a technology fully, agronomic, economic, statistical and farmer evaluations must be made. The importance of each evaluation depends upon the objectives of the research and the stage of the research process.

Although much attention has recently been paid to collecting information on farmers' perspectives, one of the key measurements which is always required is that of yield. Ultimately, the farmers' goal is to produce enough food to meet his/her requirements. The farmer's opinion of how a crop produces its final yield (at harvest, after storage etc.) is vital to test the robustness of the technology and to assess its acceptability to producers. An accurate and precise yield measurement is required so that production can be compared from different technologies used by the same farmer or to compare similar methods between locations. Reliable assessments of trade-offs between yield and other indicators of production, such as, greater market sales or increased need for labour, also require accurate yield measurements.

Source: PLA Notes (1997), Issue 29, pp.19–22, IIED London

When scientists are estimating yield from a farmer's field, both the area used to produce the harvest and the harvest weight need to be measured accurately. Under many circumstances neither measurement may be easy to make. Areas can be marked out at the start of a study or just prior to harvest. Yields may have to be recorded in local units, using local measures, and converted to standard units, at fixed moisture levels, for purposes of comparison. One of the difficulties faced by scientists is that there is little information available on how large harvest areas should be, and, how many they should use in order to obtain reliable estimates of yield.

The literature associated with agricultural research seems to suggest that measurements from farmers' fields should come from harvest areas which are larger than those traditionally used on experimental stations. It also suggests that one measurement for each field can be sufficient. However, measuring farmers' yields from a research and development project in which the farmer has participated in, for example, the choice and implementation of components of the technology package, is identical to measuring farmers' yields in a production survey. The only difference between these measurements is their end use.

The established literature on the estimation of crop yields from farmers' fields suggests that harvest areas should be in the order of 100 m^2 but that it is better to have two harvest areas of 50 m^2 than one area of 100 m^2. The second harvest area serves several purposes:

- it reduces bias in the yield estimate (this can be by as much as 50%);
- it allows location variation to be taken into account; and,
- it allows for a check on the reliability of harvest yields and to highlight peculiar values.

Our recent work, using vegetable yield data from on-farm trials in Jamaica[1], suggests that harvest plots should be between 75m^2 and 150 m^2, depending on the crop, and that precision of yield estimates can be greatly increased by use of a second harvest unit (see Box 1). Thus, examination of harvest data from on-farm trials results in similar guidelines to those given by surveyors.

If yield estimates from participatory on-farm experimentation have features common to those obtained from surveys, what else may they have in common? Yield measurements obtained from measuring produce from an area (which is less than the total crop area planted) result in estimates from what is known as crop cutting. This method has been much criticised as it invariably results in over-estimation of crop yield, typically in the order of 30%. Major reasons why they are inaccurate include the following:

- It is not always easy to decide if plants at the edge of the measured area are or are not part of the area under investigation. If the area is small, edge effects can become a major source of error, hence the need for large plots.
- Harvest areas must be chosen at random from the field under investigation. Non-random selection, particularly if plot size is small, can distort the estimated yield.
- Yield estimates take no account of storage or transportation losses, and so may not reflect the yield which can be used by the farmer.

It is convenient, but not necessarily wise, to assume that yield data collected from farmer-run trials can be incorporated into economic analyses of a technology. The problems of scaling up data from small plots is well known. Thus measurements from 1m^2 samples from farmers' maize terraces may be multiplied up to compute national yield statistics but if they are not measured precisely that imprecision will be multiplied up also (see Box 2). Although the weighting of yields by harvest area can help to improve the overall yield estimate, it may result in some values being influential on account of harvest area rather than being typical of the location under study.

[1] Data from the Rural Agricultural Development Authority/Soil Nutrients for Agricultural Productivity, CIDA funded project; used with permission.

Source: PLA Notes (1997), Issue 29, pp.19–22, IIED London

Box 1

HARVEST AREAS USED IN JAMAICAN ON-FARM TRIALS

Crop	Average area used in the study (m^2)	Suggested harvest areas for on-farm trials (m^2)	Average areas used for on-station trials (m^2) in Jamaica
Cabbage	37.1	75	16.7
Peanut	67.2	300	14.9
Sweet pepper	39.7	100	50.2
Tomato	48.4	150	5.7
Yam	31.8	100	15 plants

About 100 on-farm trials were conducted in Jamaica to assess fertiliser response to a range of domestic crops (land availability was not a constraint). The trials were laid out according to standard statistical practice. Analysis of the results showed that much larger plot sizes would have enabled more precise yield measurements to be obtained. The importance of repeating the trials at different sites was also highlighted. More precise yield assessments can be made when a technology is applied to more than one area. Increasing the number of harvest areas from one to two improved the precision by 45% for cabbage and 20% for yams, compared to using only one area. Using two sites with two harvest areas improved the precision by 72% for cabbage and 60% for yams, compared to using only one area at one farm.

Box 2

PROBLEMS OF MULTIPLYING UP YIELD FROM SMALL HARVEST AREAS

In St. Kitts a broccoli variety trial was conducted using small plots. Next to the trial two of the varieties were grown in areas similar in size to that of a commercial plot in St. Kitts. The kg/ha yield estimates for the two varieties were as shown in the box below. Clearly use of the yields estimated from small areas could give quite misleading results.

Variety	**kg/ha extrapolated from small area**	**kg/ha extrapolated from large area**	**% error in small area estimates**
A	6,320	3,480	+82
B	6,530	4,800	+36

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Implications for participatory research

Given the circumstances under which participatory research is done, researchers must be aware of the difficulties of collecting unbiased yields. It is unlikely that an entire field will be available to test a production package. Therefore, scientists should attempt to collect at least two yield values from large harvest areas representative of the farmers' field. If these areas cannot be chosen at random, the yield may result in biased estimates of the 'true' yield. Even if large areas are used, care must still be taken at harvest to reduce bias arising from edge effects. This may require more supervision than one may wish to impose, but if poor quality data are collected, they will degrade the value of any agronomic, economic or statistical evaluations, as well as the understanding of farmers' evaluations. Even under favourable circumstances, the limitations of yields obtained from only part of a farmers' field should be remembered. There are other implications concerning size of test area and farmer's attitudes to a technology. These concern the extent to which the size of the area to which the technology is applied can influence farmers' responses.

Are farmers' attitudes similar when they are based on what they see from a single small area compared to seeing several large areas? Would a farmer respond in the same way if he/she sees a small, bad patch in a small area compared with seeing a large, bad patch in a larger area?

If there is only one area to which the technology is applied, will he/she respond in the same way if he sees the crop response in two areas, particularly if one is favourable and the other less favourable? If not, would conclusions about the technique be changed and if so, which set of responses would be regarded as best representing the farmer's reaction? (see Box 3).

Presumably there is an optimum amount of information which the farmer requires to make a firm decision; if so what is it? How the requirements for large areas are met when land area is a limiting factor will remain a headache which will require the researcher's skill to solve, or he/she may need to resolve not to collect data which may be unreliable. At least the researcher must be aware of the risks taken when observations are made from small plots.

BOX 3

Opinions and attitudes are obviously subjective. Most of the information which the brain receives comes from our eyes. However, it is well known that our eyes are often deceived through optical illusions. Consider the simple case of choosing a patterned material for a dress. How does our opinion of the pattern and colour change when we see one small area, two small areas or a large area of the material? What we 'like' can change as we see more of it. Presumably similar changes can influence what the farmer likes; if so, the size and number of test areas could have a critical influence on farmer response for some characteristics.

Conclusions

Estimation of harvest yield from farmer participatory research programmes has much in common with yield estimation from survey work. In order to obtain unbiased estimates of yield, yield should be estimated from the entire field under investigation. When this approach is not possible, large duplicate harvest areas should be used. These must be chosen at random from the study field and care must be taken to distinguish between the recorded yield and yield available for the farmer's use.

Lack of such rigour typically inflates yields, results in unreliable economic estimates and incorrect information being passed to farmers. Size of test area may influence farmers' perceptions of success of new technologies. All of these factors will affect technology selection in on-farm trials and should be considered early in the planning stages of the research with the farmers.

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