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THE USES OF ON-FARM TRIALS IN A CROP IMPROVEMENT PROGRAM

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by

Roger A. Kirkby
Senior Program Officer
Crops and Cropping Systems
IDRC, P. O. Box 62084, Nairobi, Kenya



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Well-managed research stations have become a key tool in agricultural research, since a research scientist working at a station is able to control the conditions under which new agricultural technology is devised and tested. Appropriate experimental designs and statistical procedures enable the scientist to distinguish among large numbers of new varieties or agronomic treatments, many of which may differ little from one another in their yield performance. Differences among varieties in their responses to carefully managed combinations of crop husbandry treatments (fertilizer levels and weeding frequencies, for example) can be assessed.

However, the conclusions from this research are often difficult to extrapolate to nearby small farms, where an even greater range of growing conditions is certain to be found. This variation in growing conditions is likely to include soil types, rainfall and climatic conditions, previous cropping history that may affect fertility and weed flora, and crop management practices determined by each farmer's access to labour for weeding or to cash for purchasing fertilizer. A country such as Kenya may have a large enough number of experiment stations and substations to represent principal soil types and climatic zones, while others such as Ethiopia seek to expand their network of stations so as to cover previously neglected areas of the country. Economists can be added to the staff of these stations in order to document and quantify the farmers' present use of resources in producing the specific crop, their allocation of available resources among their different crops and other enterprises, and to describe particular preferences for taste or seed colour.

All too often, however, these procedures by crop scientists and economists have failed to predict farmers' eventual reaction to a new recommendation received from extension agents: until a farmer is offered the choice, experiences whether and how the new technology is compatible with his needs and his other activities, and adopts it at his own expense, we are unable to say that a technology is "proven". The use of on-farm trials gives us a complementary research tool with which to increase the cost-effectiveness of research based at the station. Widespread use of on-farm trials for food crop research in Africa is not new (see Stewart, 1947), but it is a procedure that only recently has become accepted as a standard element of crop improvement programs and one that can fulfill several distinct functions.

Objectives of On-Farm Experimentation

On-farm trials should be designed to improve the stepwise development of farmer recommendations, in the following ways (Stroud, 1985):

1. Diagnosis: Improve understanding of farmers' circumstances and multiple objectives.
2. Design: Encourage quicker and more accurate feedback.
3. Testing: Accomplish a more realistic, rigorous testing of proposed technologies under trial.
4. Diffusion: Start to involve extension with research.

Unfortunately, much on-farm experimentation does not achieve all these objectives. This is because a crop improvement program may not have appreciated the full potential, particularly for the first two objectives given above, and may consider the last two objectives to be the responsibility of extension services rather than of research.

In the following sections, each of the four stages will be examined and examples given of how on-farm trials may be most usefully incorporated into a crop improvement program, and the implications for the management of those trials.

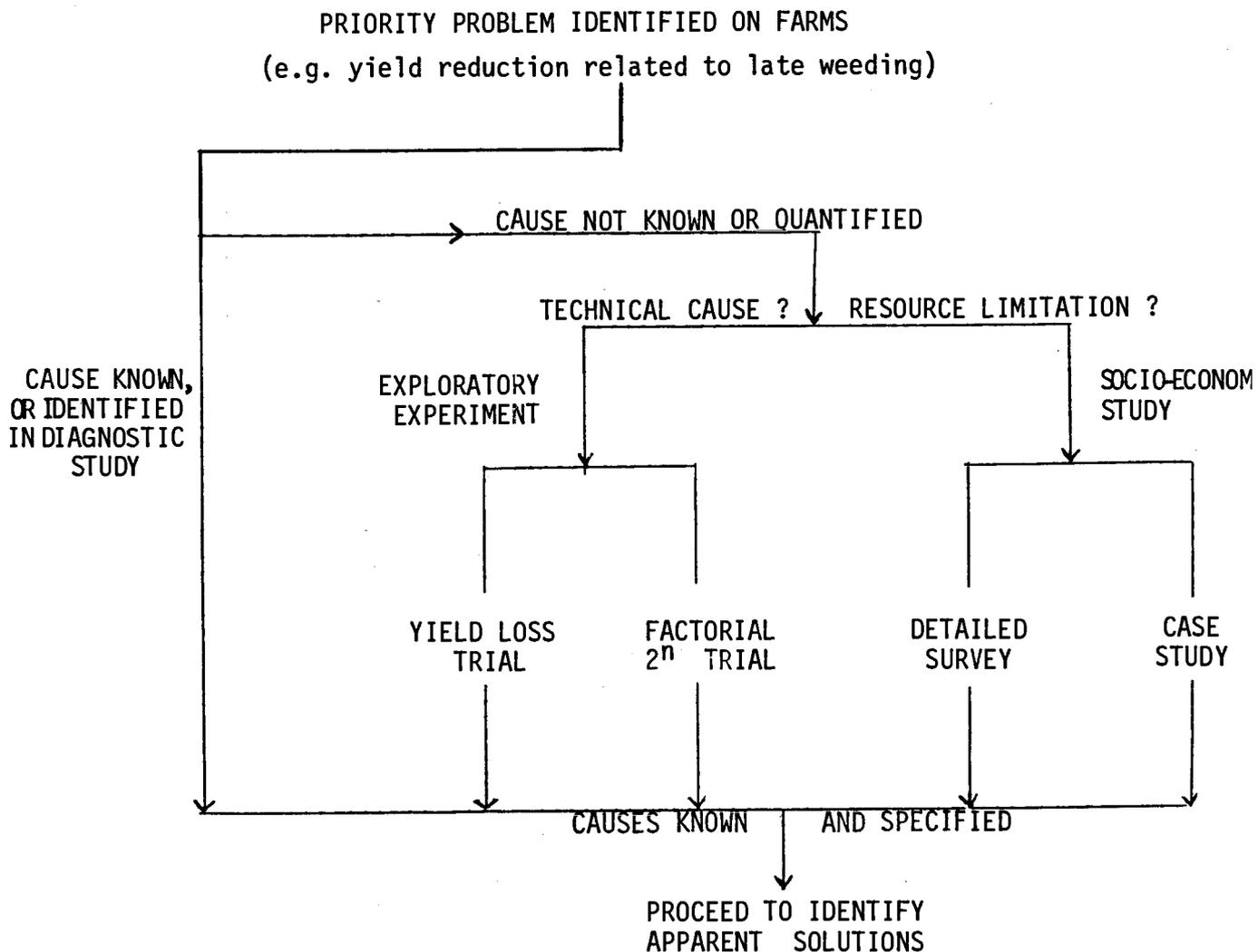
Stage 1: Diagnosis

A crop improvement program needs to seek information from several sources in order to plan appropriate technical objectives, which in turn determine plant breeding strategy and selection criteria. A regional meeting of crop improvement programs in Eastern and Southern Africa concluded that "initial sources should include existing data on production, consumption, marketing, demographic trends, and climate and literature searches. In the absence of adequate data, a survey is an important tool in both crop improvement and farming systems research programs and should be used by them when necessary. The type of survey required will depend upon the nature of the problem, e.g. a formal questionnaire-type survey can provide a quantitative assessment of the farming conditions of a region, whereas informal discussions with farmers may be particularly useful for providing insights into their understanding of their needs" (Kirkby, 1984).

Some technical constraints to crop production are unlikely to be recognized during a response survey of farmers: for example, nematode pests. More commonly, the survey and an accompanying inspection of farmers' fields identifies a problem (e.g. low yield) but is unable either to ascribe an underlying cause to the problem with certainty, or to estimate which of two or more factors contributing to low yield (e.g. pest attack and low fertility of the soil) is of sufficient economic significance to warrant specific treatment in the design of the research program.

In such instances, field experimentation may be required as soon as possible in order to verify, separate and/or quantify the effects of those factors already suspected to be important causes of the problem. These exploratory experiments often need to be conducted on farms to ensure that the conditions are representative, and a few well-chosen sites should be adequate. Trials need to be managed by the researcher, but farmers may need to be consulted during the season.

Figure 1. Understanding the underlying cause of a crop production problem



(Source: modified from CIMMYT, 1985)

Stage 2: Design

Initial design of breeding, agronomy and plant protection objectives in a new crop improvement program must depend on the best diagnosis available that time concerning the problems faced by farmers, the resources that could be utilized more efficiently, and other opportunities for research impact. Fortunately, our understanding of the complexities of these problems and opportunities improves with experience, and the use of experiments conducted under more realistic conditions can be expected to hasten the acquisition of relevant experience. This situation allows any necessary program readjustments to be made sooner than would be possible if research were confined to experiment stations until results are passed to extension.

A lesson in how the use of an appropriate type of on-farm experiment gives quicker feedback to research objectives is given by ICARDA (1984) in the case of lentil agronomy. On-station research had shown that earlier sowing of the lentil crop, as soon as the rains begin, increased yields; yet farmers were not interested in this innovation even when on-farm trials, carefully managed by the researchers, confirmed the yield increase. Only when researchers left the management of the on-farm trials to the farmers was it realized that farmers, by planting later, avoided an extra weeding since flowering occurred after the end of the rains. From the farmers' point of view, the extra weeding made the yield increase uneconomic.

Criteria that affect acceptability need to be incorporated into the program from the start. An excellent example from pigeonpea breeding in Kenya is provided by Onim (1981), who planted out a plot of mixed types on a farmer's field and requested local people to select the plants and the grain types that they preferred. The preferred bold, white seed character was later incorporated as a requirement into the breeding program for earlier-maturing varieties. Close contact and discussion with farmers, procedures that require a sympathetic and patient approach, may reveal criteria that are well beyond those related to yield measurements taken on research stations: in Zanzibar, for example, preferred characteristics in cassava variety selection now include taste and rapid growth of leafy shoot tips, shade tolerance (under coconut) and ability to suppress weeds through growth rate and branching habit (Makame and Begg, 1984).

Stage 3: Testing

On-farm testing of a proposed new technology should be a requirement before it can be recommended for widespread use. A valid program of testing will assess performance under a wider range of agroecological and crop husbandry conditions (representative of those to be faced if the technology is adopted by farmers) and will enable both researchers and farmers to determine the compatibility of the new technology with other aspects of the farming system, particularly if increased labour or purchased inputs are required.

If on-farm testing is confined to evaluating a finished product after the end of an existing sequence of testing at research stations and in multilocational trials, release of a new recommendation will be further delayed; in the event of its rejection, on-farm testing conducted at a stage when the researcher is still uncertain which is best of several promising new varieties or practices, can be extremely helpful in making the most relevant final selection. This expansion of the conventional evaluation process sometimes results in more than one variety being selected, as a consequence of unsuspected differences among farmers in their precise needs and in the complexities of farming systems.

Since one objective at this stage is to expose the new technology to a wider range of agroecological conditions, performance across many sites becomes of much greater interest than measurement of performance at any one site. Given the staff constraints faced by every improvement program, research resources are usually most efficiently utilized in trials dispersed across a large number of farms where only one or two replications are placed at each farm. This reduction in the number of plots per farm also helps achieve another objective, which is to engage the farmer as the primary evaluator of the technology, a situation that requires his full understanding of the specific objectives, treatments and layout of the experiment. Use of a plot size larger than normal is also necessary; the feasibility of a treatment for which labour requirements are expected to be different from the farmer's treatment can only be assessed meaningfully if the farmer is given the opportunity to test the experimental treatment on a sufficiently large area, perhaps even on half his field.

A useful example of the advantage of dispersion of replications of an on-farm test is provided by Matlon (1984). In a comparison of three elite sorghum varieties with the local variety in a district of Burkina Faso, replications were

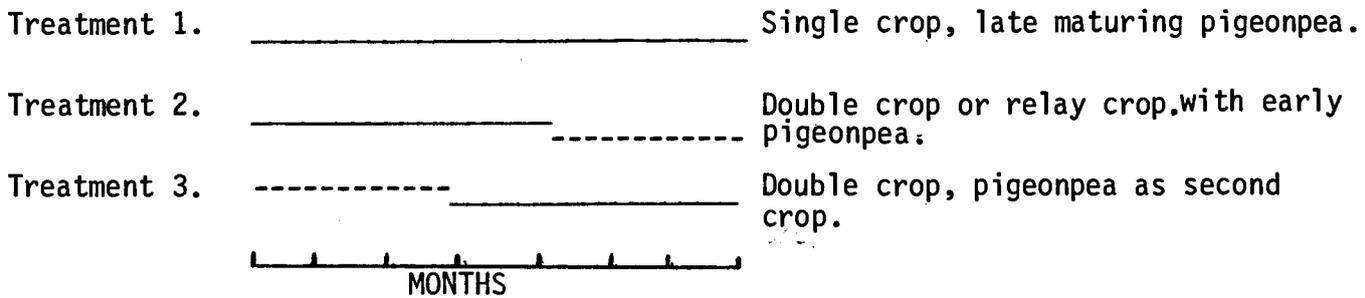
distributed on farms located at different positions on the toposequence in a gently undulating landscape. Between 25 and 30 farmers were asked to select the site as being suitable for this crop. After harvest, sites were stratified into four groups according to positions on the toposequence (plateau, upper slope, mid slope, lower slope); yields were subjected to analysis of variance within each group. Scrutiny of mean performance across groups showed that one elite variety was more widely adapted than all others except the local variety, but that another elite variety was best adapted to more fertile conditions found on mid and lower slopes. Combination of this yield analysis with other observations at each site indicated that the latter variety also performed well at those sites higher on the toposequence (i.e. sandier with inherently lower nutrient status) which received applications of organic matter; these were sites located close to homesteads where domestic and animal refuse was more available. Thus, the recommendation for sowing this new variety could be made more specific and helpful to farmers than would have been possible after conventional multilocational trials managed by research staff alone.

A relatively simple example of application of farmers' criteria is provided by the problems of developing improved groundnut varieties for southern Tanzania (Taylor, 1985). Land is plentiful, and groundnut seed is expensive, required in relatively large amounts, and is difficult to store for long periods. Farmers may be more interested in yield per plant or per kilogram of seed, than in yield per hectare. A high-yielding new variety that has been selected under conditions of high plant population may, or may not, yield relatively poorly on a per-plant basis when planted at a wider spacing. Conventional variety x spacing trials on a research station should give a reasonable first indication of performance under farmers' conditions, and later on-farm testing can be used to verify the results.

Assessing the fit of a new variety into a farming system becomes more complex when that variety has been designed to facilitate intensification of the cropping pattern. In Eastern Africa the generally low productivity of labour in many existing production systems of semi-arid areas offers both an opportunity for research to make an impact, and also a constraint to the immediate availability of extra labour at peak periods for implementing a particular innovation. The following hypothetical example involving pigeonpea may be useful here.

Local pigeonpea varieties are generally late-maturing, and researchers in Kenya (Onim, 1981) and elsewhere have identified the opportunity for introducing earlier-maturing varieties that would permit double cropping. Once an early-maturing variety has been developed, experiments at a research station may identify higher yielding cropping patterns in which full advantage may be taken of the earliness of the new variety. However, a change to double cropping implies changes in labour use patterns on the farm, and the acceptability of one or another new cropping pattern will depend upon the farmer's ability to reallocate his labour resources. While earlier economic surveys or farmer case studies may have indicated the likelihood of his being able to find the extra labour at the right time, only with on-farm testing managed primarily by the farmer himself can any conclusion be drawn. Three generalized treatments that would provide the necessary comparisons are illustrated in Figure 2; of course, actual selection of experiment treatments would be made taking account of all knowledge available for a given farming system.

Figure 2. Three generalized treatments to assess an early-maturing pigeonpea variety for farming system compatibility.



Involving the farmer in the assessment of the new variety would also enable the researcher to learn from the farmer whether other characteristics of the new variety are acceptable, concluding those characteristics that did not comprise part of its design characteristics. For example, an earlier-maturing pigeonpea provides forage after harvest at a different time of year in the case of Treatment 2 (Figure 2), possibly at a time when other forage sources are abundant. Multipurpose subsistence crops such as pigeonpea, used for grain, forage and fuelwood, require particular care in this respect, and the farmer is in the best position, indeed the only position of consequence in the final analysis, to integrate the value of the different products.

Stage 4: Diffusion of technology

While dissemination of new technology to farmers is the responsibility of extension services, researchers cannot (and should not try to) avoid the fact that most on-farm trials will have a demonstration effect, to the cooperating farmer and perhaps to his neighbours. Provided that the farmer fully understands, from initiation of his collaboration with research, that the primary objective of a trial is to experiment and not to demonstrate, and that this understanding is reinforced during visits of research staff, potential problems with failed expectations (in the event of poor performance of a treatment) can be avoided. The nature of the interaction between researcher and farmer is also crucial for eliciting fair evaluations of technology from the farmer, who must be made to feel a valued partner in this stage of research.

The overall mission of agricultural development can be achieved more efficiently if researchers and extension staff collaborate in the on-farm testing, including design as well as execution of trials. Extension staff have their more comprehensive knowledge of local farming conditions to contribute to trial design, and their future work will benefit in turn if they have been involved in the evaluation of the potential recommendation and have acquired an understanding of its advantages and of its limitations.

Conclusion

The diversity of approaches that are being used by crop researchers within the region to evaluate their promising new technology under realistic conditions on farms serves to illustrate the potential for creative thinking in research methodology. On-farm experimentation, if well done, is at least as rigorous in its application of the scientific method of hypothesis development and testing, and the drawing of relevant conclusions, as more "conventional" agricultural research in which more parameters are controlled or eliminated from consideration.

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