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PLANNING, MANAGEMENT AND EVALUATION OF ON-FARM EXPERIMENTS: ISSUES IN BOTSWANA

BY

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INTRODUCTION

In this paper, we consider on-farm experiments as those done in the context of farming systems research (FSR), or in CIMMYT terminology, as on-farm research with a farming systems perspective (OFR/FSP). In this situation, such experiments differ from classical multi-locational experiments which often just look at technical issues and have less of a systems perspective. Incorporation of the human element (socio-economic factors) and a systems perspective complicates issues relating to planning, management and evaluation of on-farm experiments.

Like many other countries in the region, FSR in Botswana has, to date, been largely project-driven, with several donor agencies involved. However, unlike some other countries in the region (e.g., Zambia and Malawi), no reorganization to accommodate FSR was made in the Ministry of Agriculture (MOA) at the time of their initiation. Instead, FSR has had to prove, over time, that it has a role to play. Fortunately, that issue has recently been resolved, and major decisions are now being made to institutionally incorporate it into the structure of MOA in such a way as to maximize the contribution it can make to the agricultural development process.

Accompanying this move is the acknowledgement that the development, dissemination and adoption of relevant improved technologies and policy/support programmes are two equally important and complementary approaches to improving the productivity, and therefore hopefully the welfare of farmers. It is also recognised that there are four groups of actors who are critically important in contributing to the process of agricultural development (Table 1).

Productive interactive linkages between planners, researchers (on-station and on-farm), extension and development staff, and farmers are critically important. Nevertheless, in many developing countries, until recently, the one-way top-down pattern shown in Figure 1A was most common. In recent years, there has been a general acceptance that the ideal model is that in Figure 1B. Unfortunately, however, the situation in many countries -- including Botswana -- is that the link to the farmer (top-down) is still stronger than from the farmer (bottom-up) (Figure 1C). There are a number of reasons why some of these linkages are

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TABLE 1: ROLES AND FUNCTIONS OF THE ACTORS IN AGRICULTURAL DEVELOPMENT

Role	Functions	Actors
Implementers		Farmers
Supporters	Transmitters	Extension Staff/
	Input Provision	Development Agencies
Provide Potential Means	Technology	Research
	Policy/Support Systems	Planning

fragile.[2]

It is apparent from Figure 1B that farming systems work can act as a broker in helping to forge linkages amongst the groups of actors. In other words, it facilitates a process and does not produce a product by itself.

In the light of the changes currently taking place in Botswana, we will spend little time in this paper dwelling on what was done in the past, when project efforts were rarely coordinated. Instead, we place considerably more emphasis on what is happening now and what is likely to happen in the near future. In this paper we stress the institutional setting -- including linkages that exist -- in which the planning, management and evaluation of on-farm trials takes place. We believe the institutional setting has -- and indeed should have -- a strong influence on such trials, and the way they are planned, conducted and evaluated. Towards the end of the paper, we will discuss some issues related to the planning, management and evaluation of on-farm trials that, we feel, are important and have not yet been resolved satisfactorily. We hope in raising them, to stimulate discussion among other participants at the workshop.

PROCEDURES FOR PLANNING, MANAGEMENT AND EVALUATION OF FSR IN BOTSWANA

Discussion of this topic can be conveniently split into two parts: within the research organization, where the procedure is becoming quite formalized; and with groups outside the research organization, where procedures are, at present, still rather informal.

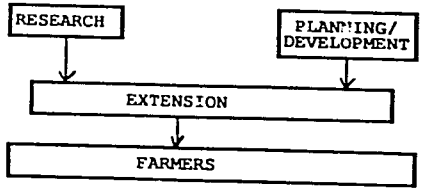
WITHIN THE RESEARCH ORGANIZATION

The system that is currently developing incorporates elements of what has been done in the past. However, the changes proposed and underway could potentially improve the impact of FSR work.

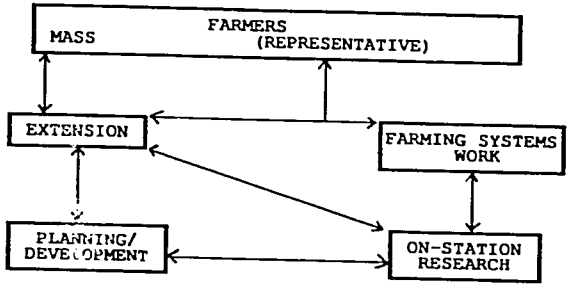
[2]. These factors include educational elitism; the desire to maintain the status quo on the part of existing personnel; institutional rigidity; evolving methodology of farming systems work, and a lack of expertise in farming systems work (Poey, 1986; Fresco and Poats, 1986).

FIGURE 1: PROCESS OF AGRICULTURAL DEVELOPMENT

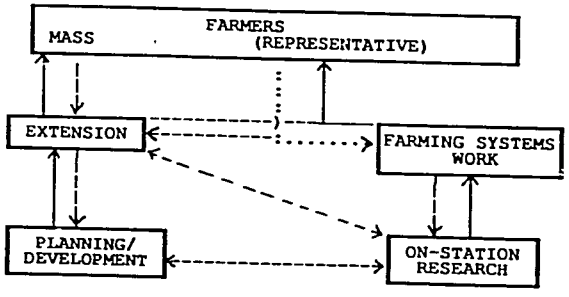
A. "TRADITIONAL" SYSTEM



B. "IDEAL" SYSTEM



C. "USUAL" SYSTEM



KEY:
——— INDICATE STRONG LINKAGES
------ INDICATE POOR LINKAGES
..... INDICATE REASONABLE LINKAGES

Source: Norman, 1988

In terms of the organization of FSR, two significant decisions are in the process of being implemented:

(a). All farming system teams will be in one department, DAR.[3]
(b). A national coordinator for FSR will be appointed in DAR.

There are obvious merits in appointing a national coordinator, and having all the teams under one department. As a result comparability, collaboration, and coordination of farming systems work should be enhanced. Until now there have been no formal links encouraging this, although, for a number of years personnel on the various teams have informally met twice a year, once in a meeting at which FSR issues were discussed, and the other being an on-farm workshop hosted by one of the FSR teams. The decision to place all the teams in the research, rather than the extension department has our support. Obviously, the strongest links are always within a department. We believe, that there still remain considerable challenges in developing relevant technologies for limited-resource farmers in the harsh climatic environment of Botswana. Therefore we believe the decision is the correct one, since potentially the strongest links should be between on-farm and on-station research work.

In the light of this, it is perhaps not surprising that the Director of DAR has proposed that a series of sub-stations be established where staff members will be responsible for on-station and on-farm work. Thus, the recent decision to institutionalize FSR in Botswana is resulting in strategies to encourage greater integration and coordination of FSR work.

At the same time, there is a move to improve the planning, management and evaluation of research as a whole.[4] The approach, that is developing, involves the following[5]:

(a). A number of interdisciplinary research groups, based on specific commodities or themes are being formed[6] which include representatives of both on-station and on-farm research and possibly extension. These groups will plan, manage and monitor the trials that are approved for their group.[7]

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[3]. Until now, two of the farming systems teams have been in Department of Agricultural Field Services (DAFS) (i.e., Farming Systems Southern Region [FSSR] and Molapo Development Project [MDP]), and two have been located in DAR (i.e., Agricultural Development Ngamiland Project [ADNP] and ATIP).

[4]. Currently the plan applies only to the Crop Production Division in DAR, not the Animal Production Division.

[5] The following summation represents our perception of what has happened, and what is likely to happen in the near future in DAR. However, minor changes may be introduced as a result of an ISNAR review which is likely to take place in early 1990.

[6]. Among those currently proposed are: cereals, legumes, horticulture, vertisols, soil and water management, and possibly farming systems research.

[7]. There has in fact, been one group, a National Tillage Team, that has been meeting successfully on a regular basis for over a year. This team, consisting of research and extension/development agency staff, has been collaborating on a multi-locational trial, at nine different sites -- eight of which are on farmers' fields -- throughout the country. The main objective of the trial is to systematically compare different tillage treatments designed to improve water available to the plants.

(b). At the Crops Division annual meeting -- attended by representatives of research, extension and possibly other agencies in MOA -- the research groups report results of the work undertaken during the last year, and seek formal approval for the proposed work programme to be carried out during the coming year.

(c). It is likely that proposals on recommended new technologies will be presented, with supporting evidence, from the research groups to the recently revitalized Recommendations Committee. This committee is to comprise of research and extension personnel and is likely to be chaired by the Director of DAR. If approval is granted, the technology becomes officially accepted for extension and an Agrifact -- a recommendation leaflet -- is created or modified. This is then published by the Department of Agricultural Field Services (DAFS), and distributed to extension staff (i.e., Agricultural Demonstrators) for dissemination to farmers.

OUTSIDE THE RESEARCH ORGANIZATION

Equally critical in ensuring pay-off from on-farm experimentation, are the links to farmers, extension staff and planners/development agencies.

1. Links With Farmers

Because farmers are the ultimate clients of results from experimental work, FSR workers need systems designed to:

(a). Ensure that farmers have a relevant input into the planning, implementation and evaluation of on-farm experiments.

(b). Create, in conjunction with others, particularly extension and/or development agency staff,[8] preconditions conducive to farmers being able to benefit from the improved technologies -- such as farmer training programmes, ensuring that the necessary external inputs are available, etc.

In actual fact, a number of the initiatives developed by the farming systems teams in Botswana, contain elements under both (a) and (b) above. For example, a trial that is both managed and implemented by the farmer, enables him/her to evaluate it and to become familiar with the advantages and disadvantages of the technology. Farmer groups -- both research and extension-led (Norman, Baker, Heinrich and Worman, 1988) -- have received a great deal of emphasis in recent ATIP activities. Farmer field days, at which farmer group members explain the trials being visited, have also become a regular feature in the villages where ATIP operates.[9] These initiatives which explicitly include farmers in planning, managing and evaluating trials, have

[8]. In Botswana, such staff are particularly significant because of a major development project, the Arable Lands Development Project (ALDEP) which offers highly subsidized packages to limited-resource farmers. These packages, which are designed to improve the productive capacity of farmers, include draught power, implements, fencing, water storage tanks, etc.

[9]. In ATIP, we concentrate our trial work in three villages in the Francistown Agricultural Region in the north of Botswana, and another three villages 250kms to the south, in the Central Agricultural Region. Each year, on average, more than 300 farmers are involved in survey and trial activities in the ATIP villages.

been stimulated, in part, by criticisms that FSR workers were increasingly failing to incorporate farmers into the research process (Chambers and Jiggins, 1985).[10]

2. Links With Extension/Development Agencies

Like most countries, Botswana is faced with a situation where the MOA is divided into a number of departments, e.g., research, extension, planning, etc. Control is exerted through these departments and is, of necessity, "vertical" in direction. Since FSR teams in Botswana are in the process of being located within DAR, linkages with other personnel in the department can intrinsically become stronger and more easily formalized. However, the development of "horizontal" linkages with extension and developmental agency personnel in other departments, is more challenging.

Originally, it was believed that the establishment of a Research Extension Coordinating Unit (RECU) could facilitate such linkages. However, there are a number of factors that are important in determining whether or not such a unit can be effective. These include whether the staff are of sufficient seniority to command the respect of staff both in extension -- where the unit is currently located[11] -- and research, and whether the unit has the authority to carry out its responsibilities. Questions with respect to these issues are now being raised in MOA, and hopefully, as a result of recommendations in a recent Agricultural Sector Review (Edwards, Amani, Frankenberger and Jansen, 1989), decisions will soon be made that will enable RECU to play a more effective role than it has to date. Thus, although the need for developing these "horizontal" linkages has been recognised, they are difficult to establish.

Indeed, it is also important that while furthering the development of these "horizontal" linkages, FSR workers do not inadvertently ignore or alienate the relationships within their own institutions. Therefore, it is necessary that both the "vertical" and "horizontal" linkages be recognized as legitimate (i.e., be formalized rather than being based on personal relationships) if FSR is to be successful.[12]

At present, the "horizontal" linkages that are developing in the areas where Botswana FSR teams are stationed, are still largely informal in nature. However, the situation is gradually changing with the realization by all sides, that such linkages are beneficial to the agricultural process.

Examples of linkages that are developing in Botswana include:

(a). Discussion of the research programme -- both results and proposals -- with key extension/development agency staff in the regions where the FSR teams are working. This enables such staff to make comments on plans for, and evaluation of, on-farm experiments. Somewhat related to this, are two additional initiatives:

-- In the Francistown Agricultural Region, the Regional Agricultural Officer, has instituted an annual Regional Coordination Meeting, where research, extension and NGO

[10]. A more recent publication gives many examples of how farmers can be effectively included in the research process (Chambers, Pacey and Thrupp, 1989).

[11]. To be effective, it probably should be located outside the two departments involved.

[12]. Currently, a proposal is being prepared for the establishment of more formalized linkages in Botswana. Obviously such linkages will only materialize if they are supported by top personnel within the existing institutions.

representatives discuss plans and programmes of the different organizations with the aim of improving communication, identifying complementarities, and resolving potential conflicts.

-- In the Central Agricultural Region, at the request of the Regional ALDEP Manager, ATIP organised a field visit to the trials, for him and the District Agricultural Officers in the region. It has been proposed that this should become an annual occurrence.

(b). Direct collaboration with extension/development agency staff in planning, implementation and evaluation of certain trials, such as the National Tillage Trial.[13]

(c). Joint organization of Farmer Field Days, particularly in the villages where the farming system teams operate.

(d). Joint organization -- with FSR teams hopefully playing more of a supportive rather than a leading role -- in farmer training initiatives such as farmer and extension staff "hands-on" training courses, technology competitions for farmers at agricultural shows, extension-led farmer groups, etc.

3. Links With Planners

The link to planning is developing slowly. A formalized system already exists, whereby policy issues are channeled to the MOA Policy Committee through the relevant departmental director. However, day to day links have tended to be more informal. For example, farming systems personnel have been requested to comment on such matters relating to consultants (i.e., terms of reference, reports produced by consultants), and on proposed developmental initiatives. Additionally, at the request of the Chief Agricultural Economist, farming systems teams have carried out an evaluation of the development programmes (ATIP, ADNP and FSSR, 1988).

ISSUES COMPLICATING THE PLANNING, MANAGEMENT AND EVALUATION OF ON-FARM EXPERIMENTS

There are a number of issues that relate to the above discussion, and have a direct bearing on the planning, management of on-farm experiments. They are not always explicitly considered, but the way in which they are resolved can have a critical impact on the effectiveness of the links between on-farm and on-station research, and with links outside the research organization. Three issues that we consider important are:

(a). Location and experimental design.
(b). Multiple clients for trials.
(c). Evaluation and technology transfer.

Issues (a) and (b) have particular relevance for planning of trials, issue (b) for management/implementation of on-farm trials, and issues (b) and (c) for the evaluation of on-farm trials.

It should be noted that, in our opinion, these issues have not been satisfactorily resolved. One of the major reasons, of course, is that their satisfactory resolution requires the support of others besides FSR workers.

[13]. For details about this, see footnote 7.

LOCATION AND EXPERIMENTAL DESIGN

When planning a trial to address technical issues, it will usually be managed and implemented by researchers, and have a standard experimental design, e.g., randomized block, latin square, etc. However, there are a number of important issues that need to be considered:

(a). Should the trial be located on-station or on-farm?

(b). What should be the levels of the experimental, but more particularly, the non-experimental variables, used in the trials?

(c). What evaluation criteria should be used in screening technological options?

Seeking the answers to these questions provides an ideal opportunity for collaboration between station-based and FSR researchers.

In general, we believe that trials, designed to answer cause-effect relationships, should, whenever possible, be carried out on experiment stations. The reasons for this include; lower implementation costs (e.g., in terms of logistics, time, etc.), and potentially better control (e.g., in terms of easier supervision, easier maintenance of ceteris paribus conditions, etc).

However, there are occasions when conducting such trials on farmers' fields is highly desirable, and sometimes even essential. Such a situation arises if it is felt that the special environmental situation of the experiment station does not provide a realistic environment for testing a technology. Would the technology fail completely if it were then transferred to farmers' fields? For example, a great deal of herbicide work probably needs to be done on farmers' fields where the weed complex is likely to be very different from that on the experiment station.[14] At a minimum, FSR teams could provide monitoring data on the technical environment found on farmers' fields, so experiment station researchers can assess environmental differences.

Results from cause-effect type research could perhaps be more relevant if researchers included in the levels of their experimental variables, those that farmers might actually be able to implement.[15] If all levels of input required are too high for the farmers to adopt, then the research may have relatively little relevance without special support programmes for farmers. This applies not only to external inputs like improved seed or fertilizer, but also to internal inputs such as household labor availability.

A closely related consideration is what should constitute the experimental and non-experimental variables, in technology development work, in researcher managed and implemented trials, particularly on experiment stations. It is not usually possible to assume that the "non-experimental variables" will be the same for on-station and under farmers' conditions. For example, seed bed preparation is often much better done on experiment stations, but this usually is considered a non-experimental variable in crop breeding programmes. Varietal testing under

[14]. The National Tillage Trial, mentioned in footnote 7, is being undertaken mainly on farmers' fields, so as to test the trial treatments on a range of soil types.

[15]. There is, of course, justification for having a range of levels of experimental variables that go beyond what farmers are likely to adopt. This is particularly relevant if it is a design type experiment used to estimate response curves. Also, this approach can be justified, if the results from responses at higher levels are likely to be used in an attempt to influence planners to change the support systems, so that farmers can use the specific inputs at a higher level.

such conditions can give very different results from what would occur if the seed bed preparation more nearly approximated that generally used by farmers.

We would argue that it is important, ex ante, to evaluate whether the levels of the non-experimental variables are likely to influence the relationships being examined between the experimental variables. Special justification should be made if the levels of the non-experimental variables differ significantly from what the farmer is likely to be able to achieve.[16]

Finally, evaluation criteria on experiment stations are generally confined to yields per unit area, but this is not always the relevant criterion to use for the farmer. For example, in Botswana, many empirical studies have shown that labour, particularly during certain peak periods, is often more limiting than land. In farming systems where both land and labour are available, the returns to additional cash inputs might be the most important constraint facing a farmer. In drought prone environments, it may be most appropriate to consider the returns to the net soil-water balance over a whole season. Obviously on small experimental plots, it is often difficult to bring into play other evaluation criteria that are important to farmers. However, whenever possible, consideration of other criteria can be very important in ensuring that potentially relevant technologies are not rejected before they can ever be screened at the farm level. FSR work can potentially aid experiment station-based staff in deciding on evaluation criteria which adequately reflect farmers' concerns. If such evaluation criteria cannot easily be applied in an experiment station-based environment, it provides justification for complementing or supplementing on-station work with trials on farmers' fields.

Thus, to be truly effective, collaboration between FSR teams and component station-based researchers must go beyond adaptive testing by FSR teams, and the feeding-back of information to experiment station researchers. Experiment station-based research often involves, implicitly or explicitly, putting components together in packages. The major advantages of packages include the complementary or synergistic effects between the components. The disadvantages of packages are the complexities of implementing them, and the likelihood of their being inappropriate to farmers. Thus, when packages are put together, it is important that the components are assembled in a way that they are based on an understanding of the main effects and first order interactions for each component, with non-experimental variables being held at the farmer's level. Where packages contain components heavily dependent on interactions, which at the same time compete heavily with resource allocations in the system, an incremental approach to the recommendation and extension of the package is required (Collinson, 1972). Thus, it is important for experiment station-based researchers and FSR teams to work closely together to ascertain what step-wise approach to the adoption of relatively complex technologies could be used. While experiment station-based researchers are often in the best position to know the interactions between the various components, FSR teams can, through collaborative work, help design step-wise approaches for introducing technologies. They can also design fall-back strategies[17] if farmers deviate from the proposed recommendation. Such collaborative work is very important in widening the possible applicability of packages to the needs of larger numbers of farmers.

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[16]. For example, in the National Tillage Trial, described in footnote 7, it has been decided to keep the treatments as weed-free as possible so that they do not complicate an analysis of differences between the tillage treatments in what is a design-type trial. It is recognized however, that farmers may not be able to create a weed-free environment. Therefore, measurements are being made of the time required in each treatment to keep the plot weed-free.

[17]. Later in the paper we refer to these as conditional clauses.

MULTIPLE CLIENTS FOR TRIALS

As has been emphasised in an earlier discussion, FSR workers tend to have multiple clients, who they interact with on a day-to-day basis -- namely farmers, station-based researchers, extension and development agency staff, and sometimes planners. We have found, over the years, that similar types of trials do not have equal appeal to all the clients. As a result, we make substantial use of three different types of trials. These trials can be differentiated on the basis of who manages and who implements the trial, i.e., researcher (technician) or farmer (Table 2). Thus three types of trials are possible:

(a). Researcher managed and researcher implemented (RMRI).
(b). Researcher managed and farmer implemented (RMFI).
(c). Farmer managed and farmer implemented (FMFI).

RMRI trials are the same as those conducted on experiment stations. Therefore, the level of testing achieved meets the standards demanded by experiment station-based researchers. However, FMFI trials are the most satisfactory for the farmer, and provide the most practical test of the technology. Due to management and resource constraints, yields or returns will diminish from the RMRI to the FMFI level. The information in Table 2 notes the major differences between RMRI work -- mainly the preserve of experiment station research -- and RMFI and FMFI trials which emphasize on-farm work. For example, the table implies differences in the research objectives, methods, experimental design, types of data collected, methods and analysis, and evaluation criteria. It is important, for example, to understand that cause-effect relationships and "hard" data are more easily obtained from RMRI work. However, farmer attitudes and inputs into the research process are more easily obtained from RMFI and FMFI work undertaken on farmers' fields. Once these differing roles are acknowledged, it is easier to recognize the complementarity of the different types of trials, and the use of appropriate criteria for evaluating the value of research.

If station-based researchers, used to RMRI type trials, don't accept the characteristics of the different types of trial, this will convince them that the experimental procedures are poor, and hence give rise to their concern about high coefficients of variation, which often result. This is because it is virtually impossible to ensure:

(a). Standardization in non-experimental variables (ceteris paribus conditions) -- particularly in FMFI trials.

(b). Measurement errors are minimized -- particularly in RMFI and FMFI trials.

However, as long as the nature, purpose and expectations of the different types of trials are properly understood, they can help satisfy the needs of the different clients of farming systems work (e.g., experiment station scientists, extension workers, and farmers).

EVALUATION AND TECHNOLOGY TRANSFER

As we mentioned earlier, the farmer is the ultimate client of the improved technologies resulting from trials -- both on-station and on-farm. Naturally, the best evaluation is spontaneous adoption of potentially improved technology tested by farmers in on-farm trials.

Various types of indices have been developed to measure this. One adoption index that has been used in recent ATIP work is calculated as the percent of representative farmers using a technology times the percent of the crop land for which the technology is used, divided by 100 (Hildebrand in Shaner, Philipp and Schmehl, 1982). This gives an index with a range from 0 to 100. A recent study in the ATIP villages in the Francistown Agricultural Region (Worman,

TABLE [illegible] EXPECTATIONS OF DIFFERENT TYPES OF TRIALS[a]

Item	Researcher Managed and Researcher Implemented (RMRI)	Researcher Managed and Farmer Implemented (RMFI)	Farmer Managed and Farmer Implemented (FMFI)
Experimental:			
Stage:	Design[b]	1st stage testing	2nd stage testing
Design:			
Complexity	Most	Less	Least
Type	Standard	Simple standard	With and without
Replication	Within and between sites	Usually only between sites but can also be within	Between sites only
Who selects technology?	Researcher	Researcher/farmer	Farmer
Participation by:			
Farmer	Least	More	Most
Researcher	Most	Less	Least
Numbers of farmers	None	Some	Most
Farmer groups	Least	More	Most
Potential:			
"Yield"	Most	Less	Least
Measurement errors	Least	Greater	Most
Degree of precision	Highest	Less	Least
Data:			
"Hard" (objective)	Most	Less	Least
"Soft" (subjective)	Least	More	Most
Determination of cause/effect relationships	Easiest	Less easy	Least likely
Incorporation into farming system	Least	More	Most
Evaluation:			
Who by?	Mainly researcher	Researcher/farmer	Mainly farmer
Nature of test	Assesses technical feasibility	Some of each plus economic evaluation	Validity for farmers - practicality, acceptable
Appeal to:			
Researchers	Most	Less	Least
Extension Staff	Usually least	More	Most
Farmers	Least	More	Most
Ease of acceptance of results of trial	Researcher	Researcher/farmer/extension	Farmer

a. There is a degree of subjectivity in some of the entries in the table, but in general they do reflect what is usually the case. In a sense, these expectations also reflect the reasons why the different types of trials are undertaken.

b. Standard multi-locational trials are also RMRI as well.

Source: Norman, 1989.

Tibone and Heinrich, 1989) indicated that in 1988-89, 26 percent of the interviewed farmers had spontaneously adopted some of the technologies that ATIP had tested with them over the years. On average, 14 percent of their crop land was devoted to the new technology. Overall, the adoption index amounted to 3.6.

This issue of spontaneous adoption raises some questions about the degree to which FSR workers should actively engage in this mode of evaluation:

(a). How involved should FSR workers get in training farmers in the details of the improved technology so that they can better perceive and reap the benefits from its adoption?

(b). Should aggressive strategies be developed by FSR workers to disseminate the improved technology before it has been approved by the Recommendations Committee at headquarters?

To date we have attempted to resolve these issues in the following manner:

(a). We recognize that because of our institutional linkage in DAR, our primary role must be in research -- in other words, the development of technology rather than its dissemination.

(b). However, we recognize that, because of the multiple clients who interact with FSR workers, we do have some responsibility in helping extension/development agency staff and farmers to create processes that will improve the efficiency of dissemination and adoption. In this sense we see our role as being supportive and catalytic rather than being one of leadership.

(c). We are obviously happy to see the spontaneous adoption of a technology as a result of our efforts in the villages where we work. However, we recognize that more complex technologies, and technologies that require essential changes on the part of farmers, will not be readily adopted by farmers without appropriate training programmes, and availability of the relevant external inputs (e.g., equipment, improved seed, etc). For example, in the adoption study referred to above, the adoption index for relatively simple double ploughing was 8.6 compared with 2.9 for more complex row planting, usually done with animal drawn equipment. This is the reason why, in the Central Agricultural Region, we have placed a good deal of emphasis on helping extension/development agency staff to train farmers in row planting. Also, unfortunately, because of the harsh climatic environment of Botswana, there is little flexibility in the farming system, because a key management factor is the ability of farmers to plough and plant when it is likely to improve water availability for plant growth, and to improve the efficiency of water use. Therefore, researchers in our situation are faced with the challenge of trying to develop relevant technologies to break a major constraint, rather than having the easier task of developing technologies that will avoid the constraint by exploiting the flexibility that exists within the farming system (Norman and Collinson, 1986).[18] Under these conditions, adoption by farmers of such

[18]. In fact, if one looks at the success of FSR to date, it has generally been more successful in more equable climates than exist in Botswana. In examining the relative success of FSR in such environments, it is apparent that much of it can be attributed to exploitation of flexibility in the farming system -- often requiring only minor changes on the part of the farmer -- rather than breaking constraints. Technologies involving exploiting flexibility in the farming system are thus more likely to be spontaneously adopted, and are less likely to require rigorous farmer training programmes to encourage their adoption.

technologies involves major changes in their farming system. For example, much of the ATIP work has concentrated on the ploughing-planting operation. However, strategies to improve water available to the plant at planting time, require more draught than the traditional strategy of broadcasting the seed and ploughing it in. Consequently, it is not surprising that the spontaneous adoption indices in the ATIP study referred to above are, in general, low because aggressive farmer training programmes have not been organised[19], and sometimes the necessary external inputs have not been readily available. Interestingly enough, in the same study, it was found that the wealthier farmers had a much higher level of adoption (i.e., adoption index of 12.0 for those owning more than 40 cattle) compared to poorer farmers (i.e, 0.2 for those not owning any cattle). Obviously, the relative risks for wealthier farmers in making major changes in their farming systems was much lower than for poorer farmers.

(d). We do not actively promote adoption of technologies that have been tested in the villages where we work. And, at the same time we do not plan on helping extension/development agency staff actively promote such technologies until the Recommendations Committee has approved them. Although we appreciate that some recommendations are likely to be locational specific, we believe that there should be independent evaluations of the proposed recommendations, taking into account national/societal interests, compatibility with actual and planned support systems, sustainability issues, etc.

(e). Our supportive role with respect to helping the extension/development agency staff disseminate technologies outside the ATIP villages, is confined to working with those technologies that are already officially aporoved recommendations. For example, in the researcher-led farmer groups in the ATIP villages, we test with farmers, technologies that are not officially recommended. However, in the extension-led farmer groups in other villages in the area, where we play a supportive role, usually only recommendations that are officially approved, are offered to farmers. Also, in the farmer training courses and agricultural shows we have worked with extension/development agency staff to help train farmers in row planting, which has been officially recommended for many years.

(f). With reference to approving recommendations, we would like to see an increasing acceptance of the following:

(i). **Incorporation of Conditional Clauses and Targeting Information.** There is often an unfortunate tendency to assume that the farmers are homogeneous in the natural (technical) environment that they face, and the socio-economic characteristics or resources they have. As a result, the monolithic technological package concept discussed earlier, has been widely advocated. It is not altogether surprising that where technological packages have been disseminated, many farmers have adopted components rather than the complete package. In such cases there is often little advice available on what farmers should do. For example, should they put a top dressing of fertilizer on when they don't weed?

[19]. In a sense, implementation of such programmes would mean that any adoption occurring would cease to be spontaneous. One interesting alternative that ATIP has tried, instead of a massive aggressive farmer training programme, is to concentrate teaching row-planting to a few farmers, who have then done row-planting on a custom-hire basis for other farmers. Because of the amount of row planting these farmers did in one year, they quickly built up their managerial skills with respect to his practice (Modiakgotla, 1989).

The return from the limited research resources[20] can be improved by:

-- Stating conditional clauses, which would say what to do under circumstances different from those originally envisioned in the recommendation. These deviations could be attributable to the farmer, weather conditions, lack of availability of some of the technological components, etc. Included in the conditional clauses are possible variations such as: a recommended step-wise approach to the adoption of the different components of the package; suggesting a number of options for the farmer to pursue.

-- Including targeting information, showing under what technical and socio-economic conditions the technology, being recommended, would be most applicable. For example, a particular technology might be most suitable for one soil type, and farmers with a specific resource base.

Thus in recognizing the diversity of farmers, farming systems research can help in developing non-blanketed, targeted and conditional clauses for proposed improved technologies. In doing so, it can potentially improve the multiplier effect of the limited research resources by providing a technology which is appropriate to more farmers through widening intervention possibilities. It is particularly important to develop a range of options in more marginal farming areas. Such guidelines, in a sense, indicate how greater numbers of farmers can more closely approach the optimal situation.

(ii). **Widening Information Base For Approving Recommendations.** The usual information required for approving recommendations consists of "hard" objective data often collected in an RMRI experimental environment. However, there is an increasing acceptance that there is a need to conduct a socio-economic evaluation as well as the more common technical analysis. We have found that, in order to more closely approach the farmers' operational environment, much of the data required are best collected in an RMFI experimental environment. However, as we emphasised earlier in the paper, there is likely to be an increase in the "softness" of the data -- therefore potentially reducing its acceptability in the technology evaluation process. Increasing amounts of qualitative attitudinal data, collected at the FMFI level, are likely to be even more suspect in such an evaluation exercise. While we appreciate the reasons for this, it is an unfortunate fact, that moves towards greater incorporation of the farmer -- the ultimate customer of our trial work -- in the evaluation process has a tendency to result in more qualitative "softer" type of data, that is less acceptable to many individuals responsible for approving official recommendations. There is obviously no easy solution to this problem, but we believe a judicious mix of hard/quantitative and soft/qualitative data may be useful in the evaluation process. Scientific objectivity, requiring many years of painstaking experimental work -- often in a somewhat "artificial" environment -- should not, we believe, be completely substituted for common sense. For example, we believe that some of the information needed for drawing up the conditional clauses and targeting information, discussed above, does not require exhaustive experimentation, but can be derived from the knowledge of trained scientists and experiences of FSR scientists working at the farm level. Resources for research are limited, and ways need to be sought to maximize the return from them so as to facilitate the agricultural development process which is often in a state of crisis. Experiment

[20]. See also discussion by Byerlee (1986) on prescriptive and auxiliary information.

station researchers are understandably conservative in making recommendations,[21] while extension staff are, also justifiably, anxious that recommendations are forthcoming on a regular basis. Since farming systems researchers work with relatively few farmers, it is important that the recommendations are formulated and passed to extension at the earliest possible opportunity in order to maximize their impact on the farming population. Although ideally it would be desirable to defer making recommendations until there has been some adoption, for reasons discussed earlier, this would result in unacceptable time delays. Rather, recommendations will need to be based largely on ex ante evaluation. Because of limited research resources and the various interest groups, devising interim best-bet recommendations, based on the best knowledge currently available to the research scientists, can be justified. These should have the proviso that they can be modified in the light of knowledge obtained later. There is, of course, an inherent danger in doing this especially if an interim recommendation has any possibility of adversely affecting the environment or farmers' welfare. However, if the appropriate interested parties are brought together, it should be possible to avoid drawing up inappropriate recommendations. This is one of the reasons we still see a role for a Recommendations Committee at the headquarter level.

CONCLUDING COMMENTS

With all the institutional and operational changes that are occurring, these are exciting times in Botswana. We are confident that the result will be a stronger institutional setting that will have a positive impact on the agricultural development process. In the paper we have spent some time emphasizing the institutional setting. In addition to our appreciating that the appropriate institutional framework is likely to be locational specific, we believe that the institutional setting is critically important in deciding on the most relevant way of resolving issues with respect to planning, management and evaluation of on-farm trials.

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[21]. Optimum recommendations drawn up after many years of work on the experiment station will in fact, given the heterogeneity within the farmers' environment, not be optimal for most farmers.

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