DATA COLLECTION SYSTEMS AND METHODS IN ON-FARM/FARMING SYSTEMS RESEARCH: A CRITICAL REVIEW*

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* Incomplete first draft for comments. Little attempt has been made in this draft to integrate contributions from the literature.

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INTRODUCTION

On-farm or Farming Systems Research[1/] has been increasingly promoted in recent years as a means of increasing the effectiveness of agricultural research systems and delivering appropriate technologies to farmers. Most FSR programs consist of at least two basic components. The first is a diagnostic stage in which farm surveys and other methods are used to identify constraints in the system and choose possible solutions to those constraints that would be feasible to farmers. The second is an experimentation stage in which possible solutions to these problems are tested under farmers' conditions. The ultimate end product of this process is information usually in the form of a recommendation to farmers on an improvement or improvements in the technology for a particular enterprise(s) in the system. To be effective, this information should be quite specific and deal with only a limited number of priority changes in farming methods, since farmers because of risk, capital shortage and learning by doing, will only make gradual changes in their farming methods.

There are also other users of information generated by FSR. Many FSR programs have identified serious limitations in technologies being generated on experiment stations and this information is fed back to experimentation station researchers to help reorient their research more closely to farmers' problems. Also farming systems researchers are increasingly directing their efforts toward providing information to policy makers on problems or inconsistencies in the policy environment in which farmers operate. In both these

[1/] We use the terms On-Farm Research (OFR) and Farming Systems Research (FSR) interchangeably in this paper since they basically have the same objectives and use the same methodologies (see Harrington).

case the information provided is again quite specific - e.g. information to plant breeders on the characteristics of a desired variety or information to policy makers on the pay-offs to making a specific input more readily available.

In each of the above cases, FSR is essentially a data collection system to generate information for quite specific objectives. Nonetheless, data collection methods for FSR have until recently been derived from traditional farm management research which has usually had quite different objectives. Following its origins in developed countries, farm management research originally focused on collection and analysis of input-output type data to improve resource allocation of individual farmers. More recently with recognition that this is not a cost-effective approach in developing countries (Collinson), farm management research has broadened its objectives to providing information to improve the micro-level basis for policy decisions (Taylor). However, as practiced, the emphasis is still placed on generating input-output type information at one point in time to have available to analyse policy questions as they arise. Data collection methods in farm management research reflect this emphasis on general input-output information. Some modifications have been made to fit the situation in developing countries, usually by more reliable (and more costly) methods, such as frequent visits or field measurement, of obtaining input-output data (Norman, Spencer).

The application of data collection methods of farm management research to FSR has at least two important limitations. First, farm management research usually generates an information "bank" at one point in time, or at regular intervals to be called on for general use. Secondly, data collection is usually usually confined to input-output information and attempts to understand the systems are made ex poste with the aid of farm models constructed with this input-output data.

More recently, economists involved in FSR have experimented with alternative data collection methods not normally employed in farm management research. One method that has been adopted is the use of unstructured informal interviews conducted by the researchers themselves. This method was initially adopted in efforts to reduce costs of following traditional survey methods - particularly the costs of training interviewers, interviewing substantial numbers of farmers and analysing data (Collinson, Hildebrand). However, other advantages of this method are being increasingly appreciated, particularly the ability for researchers to obtain at first hand a rapid understanding of farming systems.

Survey techniques now being used in FSR programs cover this wide range of approaches from informal interviews to multiple visits or cost route surveys - sometimes with direct field or yield measurement. The role of experimentation in the data collection system and the methods used also vary widely. Some of this variation reflects differences among FSR programs in the objectives, research resources, time horizon and the farming systems under study. But a large part of the variation, we believe, arises from different conceptions of an efficient data collection system to achieve the specific objectives of FSR.

The purpose of this paper is to develop a conceptual framework for designing efficient data collection systems in FSR and to illustrate the design of data collection systems in specific situations. The framework draws on the theory of the economics of information to establish some principles for evaluating the efficienty of a particular system. Within this framework, a data collection system or process is a combination of various methods or techniques of getting data each of which are used at various points in the process, usually in a sequential manner. Each of the data collection methods is defined by various characteristics which we identify and discussed. However, the design of a data collection method must be specific to the particular research situation at hand. Ways in which the research situation affect the choice of data collection systems are briefly listed. The following section then presents the general approach advocated by CIMMYT for efficiently generating information. Examples are given of how the approach was modified to fit specific situations where we have worked. Finally, we make some general recommendations for improving data collection systems and methods in FSR.

A Framework for Evaluating Data Collection Systems and Methods in FSR

The Economics of Information

The theory of the economics of information while difficult to apply formally to the design of data collection systems in FSR, does provide principles which are useful in making decisions on alternative systems and methods. First, information is generated in FSR because it has value to the user - i.e. the farmer, the experiment station researcher or policy maker. In many cases it may be possible to put an economic value on this information. For example in an area where farmers are regularly using both nitrogenous and phosphorous fertilizer, a FSR project might provide information that phosphorous need only be applied on a certain soil type and within a specific rotation. Then if this information is transferred effectively to farmers who follow the recommendation, the value of the information is the money saved from reducing phosphorous applications. Likewise, if information is made available from FSR that emphasis in maize breeding should be changed to earliness rather than yield since farmers with an early variety could plant a second crop, then we can value the information in terms of the research resources programmed for expenditure on maize varieties which in all likelihood would not have been accepted by farmers.

There are a number of principles which hold in placing a value on information in FSR. First, there is usually a time lag between expenditure of resources for generating information and the impact of the information on decisions. Part of this time lag is due to the time needed to generate information. For example, in a dry area, information on the effect of climatic variability on fertilizer response may require three or more years of experimentation. There is also a time lag when information must diffuse to a large number of decision makers as in the case of technological recommendations to farmers. The value of information from FSR must therefore be discounted by these time lags. Efficient information generation procedures will however recognize this discount factor and will place more value on information that allows farmers to increase their incomes by 10 percent annually beginning now than information that will allow income increases of 50 percent in five years time.

Second, information clearly has higher value for some variables than others. Given costs of generating information, the data collection system should be able to efficiently identify those variables about which information has most value, in order to focus research resources to obtain more valid estimates of those variables. Many times, the approach is adopted that if it doesn't cost much to collect additional information, then why not do it. The problem with this approach is that it often ignores the opportunity cost in terms of time and effort in analysing data on a large number of variables all of which are implicitly treated as having equal value. Also information is usually transferred to farmers more effectively if it focuses on only a few variables.

Third, increasing amounts of information on a specific variable usually lead to diminishing returns. That is, increasing confidence in the value of a specific variable such as the performance of a new wheat variety relative to the farmers' variety may be of decreasing value to decision makers. However, information with a higher degree of quantification and confidence intervals is sometimes easier to transfer to decision makers. For example, by informally talking to farmers in an area, we may believe quite confidently that farmers working with the official credit bank are receiving inputs late and delaying planting even though we don't have a specific quantitative estimate of this problem. However to communicate this information to a relevant bank official we may be more effective if we can say that the planting date of farmers who work with the bank is on average 10 days later than other farmers and that there is only a 6 percent chance that this difference is due to chance alone. This same problem also arises when FSR research is conducted as part of a University research program. Here presentation of quantitative tests of specific hypotheses is usually required for acceptance by university peer groups.

Implicit in the above discussion is that data collection also has a cost. These consist of financial costs (including fixed investments) and human resource cost. Most FSR projects at the national level are severely limited in both of these aspects so that cost-effective techniques of generating information become an overriding priority. Costs are associated with both the gathering and the analysis of data. Too often, researchers do not consider the cost of the data analysis - particularly in terms of time. Again costs also increase with the quantity of information generated. For example Figure __ shows sample size (assumed to be proportional to costs) in relation to the size of the confidence interval on the variable estimated.

The final principle that emerges from information theory is that information generation can be sequential with data collected in one stage of the process being used to make decisions about thevalue of further data collection.

This principle has primarily been applied in Bayesian sampling methods where prior information on the mean and variance of a particular variable is used to make a decision about further sampling from a population given expected costs and returns from the additional information. This process may be generalized to a sequential data collection system in which information from one stage is used to make decisions about which variables should be emphasized in further data collection and how much information should be obtained for each variable. This sequencing method is important in designing an efficient data collection system in FSR since the ultimate objective is to narrow down from a wide array of possibilities to a few variables on which information will be transferred to the user.

FSR as a Data Collection System

We have argued that FSR is a system for generating information for various users, most importantly farmers. The process usually employs several different methods such as assembly of secondary data, unstructured informal farmer interviews, formal surveys with questionnaires and experiments. The task of an FSR program is to allocate the limited financial and human resources among various methods over time to most efficiently arrive at specific and useful information on a few variables to be communicated to the the user(s).

Given limited resources, an FSR program must also decide between allocating all resources to a specific study area versus spreading resources over a larger area resulting in less information being obtained for each area but with potentially wider impacts.

FSR may have both short run and long-term objectives. In the short run, providing some information quickly to farmers that allows an improvement on their existing system will usually be a priority objective. In the long run, the FSR program will usually consider other users of the information particularly experiment station researchers and policy makers. FSR programs may also consider development and training in the necessary skills of FSR in order to increase the capacity for future work. Finally FSR programs may have to generate political support within the research institution for continuation of their research. This again argues for some short term results to help establish credibility.

Survey researchers in general always have the temptation to obtain as much information as possible with the idea that it might be useful in the future. This is particularly true in FSR programs precisely because FSR advocates a much broader, multifactorial approach to agricultural research that it is liable to bite off more than it can chew in the limited time and resources defined by a particular project's budget. There is, as Clay points out, danger in over-emphasizing "the system" and attempting to work on everything at once. To realize that a small farmers' management of his crops, animals and off-farm enterprises is a complicated business and that methods for its improvement are neither straight-forward nor obvious, is a vital step forward. But it is something else to propose that we attack on all fronts simultaneously. In the real world, people must work in limited time frames with well-defined objectives and budgets, and demonstrate success in as short a time as possible. If FSR cannot accomodate itself to those requirements then it has little chance for acceptance.

An efficient process will then be based on methods for diagnosing the farming systems that allow researchers to identify a few key variables that promise immediate improvements in the system. This argues for a sequential process in which a broad study of the system gradually narrows down to intensive work on priority areas. It is an iterative model, in the sense that information gathered at early stages is used to generate hypotheses on key relationships which are then tested at later stages. It is iterative also in that it allows identification of new problems and new hypotheses as the research continues. These will be basis for future data collection efforts.

Finally, an efficient process will attempt to incorporate already known information into the data generation process. In particular, we would argue that the "body of knowledge" available within research disciplines and from experiment station research must be integrated. All relevant disciplines that are available should be involved from the beginning, each offering its own point of view, prior information and suggestions for work. Through this, process research questions become identified.

We do not want to give the impression that data collection system for FSR is a complicated affair. It is only to point out that FSR is an attempt to reorganize research on a permanent basis and that data collection should be viewed in the context of a long term process. A wide range of data collection methods may be applied. Their inclusion in the data collection system must however contribute to the overall efficiency of the system in meeting specific objectives.

Characteristics of Data Collection Methods

Typically, data collection methods have been classified in terms of increasing costs - from informal interviews or "sondeos" to structured frequent visit methods. However this classification system is difficult to apply in practice because there are a continuous array of methods. For example, some methods might combine elements of informal surveys such as unstructured farmer interviews with elements of formal surveys such as random samples. Also we have argued that an efficient data collection system may consist of several methods upto and including the experimentation stage.

In this paper we choose to classify characteristics of data collection methods. The characteristics that we discuss are as follows:

a) The degree of direct observation - that is whether a variable such as yield is measured directly or is obtained by less direct methods such as by asking farmers.

b) Degree of participation by researchers. This is measured by the extent to which researchers have first hand contact with farmers and their fields.

c) Degree to which written recording is used in the data collection method. This may range from no written recording all the way to the use of a questionnaire to record questions and answers in an interview.

d) Degree of structure and specificity. This reflects the extent to which a given method elicits specific information in a particular sequence or is more open-ended and iterative.

e) Degree of quantification. This varies depending on the extent to which a given variable is quantified.

f) Degree of confidence. This relates to the standard concept of the confidence intervals to be placed on estimates of variable or tests of a hypothesis. This may be subjectively measured depending on researchers' strength of belief in their conclusions or objectively measured if a specific variable is quantified in a random sample.

A given data collection method is defined by the combination of these characters. For example, a sondeo or exploratory survey usually involves a high degree of participation by researchers and little structure and specificity and a low degree of quantification. The degree of observation and written recording varies widely. The degree of confidence, here measured subjectively, may also vary. Observations in farmers' fields employ a high degree of observation but vary substantially with respect to other characteristics. We turn now to a discussion of the merits of each characteristic.

Degree of Observation. Many (but not all) of the phenomena of interest to FSR are, at least in principle, subject to direct observation and measurement. Data collection methods can be arranged in order of the degree of observation. At the bottom of the scale are techniques which draw upon others' observations of farmers' practices. These would include such things as the review of secondary data (censuses, past surveys, etc.) and visits to local officials to get their observations about what farmers do. The next step up the scale includes all of the various interview methods which ask a sample of farmers to describe their own behavior. Next are methods in which the investigator himself or an assistant is the observer, directly observing variables such as inputs used or types of weeds in a field. And finally, the most controlled type of observation is the field experiment, in which the investigator directly observes or measures a range of data under controlled conditions through his management or participation in the experiments.

In most cases, the higher the degree of observation in a survey method, the greater the validity of the data, but the more expensive and/or time consuming the method[1/]. Researchers must take this trade-off into account when considering appropriate techniques. In some cases direct observation is the only way of obtaining reasonable data if it is needed (the occurrence of a plant disease which the farmer does not recognize) while in other cases observation is virtually impossible (yearly income) or very costly (labor time allocation). On-farm experiments, if they satisfy some of the other characteristics such as representativeness (see later section), provide some of the most valid types of information, but usually at high cost. Their expense argues for careful selection of experimental variables before beginning. Observation is also valuable when the farmer is unable to describe particular parameters. In these cases there are sometimes proxies that can be devised which increase the validity of the data without increasing the expense through direct observation. Besides proxies, the farmer's own

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[1/] In some cases however, too much observation can affect the validity of the measurements. This is the case when the observer's presence affects the phenomena under consideration - "the observer effect". Following a farmer around all day with a stopwatch may be an example of this; time allocation data of equal validity may be obtained by a multiple visit method in which the subject reports his activities to the investigator (Tripp).

observational skills can be increased, either by aiding him (showing him pictures of common weeds as part of a survey, providing him with scales to measure his harvest) or by visiting him more often so his memory will be fresher (next section).

Participant observation is a technique with potential in FSR. It has been most often used in anthropology, and in its classic form the investigator lives in a community for a long period of time, learns the language, participates in the daily activites of community members, and observes matters as unobtrusively as possible, gradually building up a corpus of data which can be analyzed and reported. This type of observation is a luxury that few FSR programs can afford, but certain aspects of the method are of greater relevance. Using participation in community activities as a way of observing things and developing people's confidence in the researcher is of value - helping to plant a trial in a farmer's field and visiting it frequently is an excellent opportunity for precisely this type of participant observation as the researcher uses the trial visit as a pretext for casually discussing a range of other matters with farmers and spending some time walking through the community (Tripp). This is a way of gaining insights into many matters that formal interviews or observational techniques could not touch[1/].

Observation of farmer's fields also has potential for wider use in FSR. At a minimum it allows researchers a first hand appreciation of farmers' yield limiting factors such as weeds and diseases which cannot readily be obtained

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[2/] Participation observation is also helpful in cases where the phonemenon in question cannot be measured. Clay speaks of the necessity of spending time in communities in Bangladesh to discover how water rights are managed, something that would be very difficult to ascertain through interviews. Attendance at meetings is also sometimes valuable for getting an idea about distribution of political power and for hearing opinions expressed and debated.

in farmer interviews. Quantitative collection of data from farmers' fields may also substitute for experimental observations. For example yield or a weed problem may be related to specific practices used by farmers. Given sufficient variability in those practices in the sample, this method may enable quite valid estimates of particular biological relationships that would normally be estimated by experimentation (see for example Pinstrup-Andersen; Byerlee, Whitehead). In general however, the method is costly, especially if formal measurement is employed or fields are not readily accessible. Some less costly observation methods based on visual estimates of variables such as yields or weed damage have been used quite successfully (Byerlee, Harrington and Marko; Byerlee).

Observation techniques are however rarely sufficient even for the measurement of a very specific variable or relationship. In particular, observations to truly reflect variability over time must be taken at several points in time. This greatly adds to costs. Alternatively observations at one point in time must be supplemented by farmer interviews to enable the results to be placed in the perspective of the year to year variability. Finally, interpretation of observations is always necessary and farmers must be approached for this. Reliance on pure observation leads, it has been said, to the conclusion that "every morning the women of the village go down to the river bank and try to break rocks with wet clothes".

Degree of Participation of Researchers. At one extreme, a survey can be completely designed in an office, given to a group of enumerators hired for the purpose, and the results analyzed back in the office. This level of researcher (non) participation is sometimes encountered but we would argue that the questions of the researchers' active field involvement is particularly important in FSR. In particular, we have argued that FSR, at least initially should be open-ended and not prejudge the variables of interest. A high degree of participation allows researchers to know at first hand the study area, formulate hypotheses and diagnose priority problems.

Also, the researchers' expertise is (or should be) greater than that of any intermediary that might be hired and therefore the researcher is likely to exercise care and judgement in identifying and recording data.

On the other hand, it is usually not a wise decision to have senior researchers spending significant amounts of time administering questionnaires to a large sample. Where specific information is being tested it may be best for researchers to design and test the instrument and have others obtain the data. Also, in certain situations researchers who are outsiders may have difficulty at least initially, in obtaining information - a locally recruited intermediary may be needed. This might occur where there is a high degree of suspicion about government officials or other strangers, where there are language differences between researchers and farmers, or where male researchers attempt to get information from female farmers or vice versa.

<u>Frequency of Data Collection</u>. Norman has suggested that data can be classified as single point if an event occurs over a short period of time or continuous if it occurs over an extended period of time. Data can also be classified as registered, if farmers readily conceptualize it (e.g. inorganic fertilizer inputs) or nonregistered if farmers do not normally conceptualize or measure a unit (e.g. family labor input or organic manure). Multiple visit data

collection methods help to reduce the time over which farmers must recall an event and are often employed for continous and/or unregistered data. Data taken by observation may also be done in multiple-visits, especially observations such as the incidence of insect problems, in a growing crop.

Observation can often substitute for multiple-visits interviews. Cassava yields - usually a continuous non-registered variable in West Africa can be measured directly in crop cuts or by multiple visits to farmers. Labor time allocation can be estimated either through observation or interviews, at one point in time or more often. Time allocation could be estimated (very poorly) by a single visit to a locality in which various activities were observed and recorded. This could be improved upon by more frequent visits, and further still by a series of random visits to a selected sample of households (Johnson). At the extreme, observation could be continuous over a period of days (and at various time of the year) with researchers following farmers through their daily routines. This is obviously the method with the highest frequency of observation and of course the most demanding in terms of research resources. Similarly, interview methods for estimating time allocation vary from single interviews in which the farmer is asked to estimate time spent during the year at various tasks (or proxies, such as asking what periods of the year are the busiest - Collinson) to more frequent visits in which farmers are asked only to recall activities in the time period since the previous visit or in a recent period of time.

Thus there are a series of considerations in deciding how frequently data should be collected. How readily can the farmer understand what is being asked for? How good is he at recalling the information? Over what time period does the phenomenon occur? Can observation be used in place of interviews? On the other side, the investigator must ask what the costs might be in terms of time, money, and imposition on farmers, and if they are justified by the extra validity gained with higher frequency.

In general, we believe that there are very few variables which are important in FSR which require the expense of multiple-visits. Many multiple-visits surveys have been set up to measure seasonal labor inputs and bottle-necks (e.g. Spencer and Byerlee) where single-visit methods (e.g. asking farmers their opinion on the busiest season) would give most of the information at much lower costs.

Use of Written Recording of Information. Data collection methods vary substantially in the degree to which information is recorded in writing. Some methods may depend entirely on oral interviews or visual observations. Information obtained in this way may or may not be recorded after the interview. At the other extrme are written questionnaires used to administer questions and record information during an interview.

We believe that whatever method is employed that regular recording of information in writing is desirable in order to preserve as much information as possible for future reference either by the same researcher or by other researchers. For example, an agronomist who visits an on-farm experiment on a regular basis learns a great deal both from visual observation of the experiment and casual conversation with the farmer, that is useful in interpreting the experimental results (Tripp). This information should be recorded regularly since the researcher himself may want a reference in future years when combining results across sites and years and in any event changes in research staff in a FSR are often quite high, and written information can easily be passed from one researcher to another.

Emphasis on writing responses during an interview may however have a negative influence on farmers' cooperation, especially if sensitive information is being recorded. This can be avoided by writing down information after the interview. With experience, researchers can even administer a short questionnaire without using written questions or notes in the interview, provided information is recorded immediately afterwards. However, with the development of appropriate interview skills, there is usually little difficulty in recording information in the interview for all but the most sensitive information.

Degree of Structure and Specificity. These two characteristics are usually but not necessarily associated in data collection methods. A questionnaire is a structured method in which specific questions are asked following the order of the questionnaire. Sondeos or exploratory surveys usually employ unstructured interview methods with questions being chosen depending on the farmers interest and the interviewers judgement. Unstructured methods also allow an iterative interview method where questions are formulated depending on farmers' responses or observations in the farmers' field. Questions in these interviews are often not very specific - that is, the same questions are not asked to each farmer.

The degree of structure and specificity required in a data collection method depends on the stage in the data gathering process. Identification of problems and formulation of hypotheses is best done with fairly unstructured methods. On the basis of this information, it is possible to use structured methods to obtain specific information or test specific hypotheses.

One of the principal strategies of FSR is to narrow a field of enquiry until a few hypotheses remain to be tested, through structured surveys, observations or field trials. In many cases researchers are probably at the point where they should be concerned "rather more with identifying the important variables rather than measuring their movements" (Hill). As much flexibility as possible should be maintained at the beginning of the research process so that these important variables can indeed be identified. This does not mean collecting large quantities of survey data, but rather spending enough time pursuing a variety of matters and gaining a general understanding of the farming system, and then narrowing the field as rapidly as possible. This argues for the importance of open-ended questions and unstructured interviewing situations.

Degree of Quantification. Once variables have been specified there is the question of the degree of quantification required to describe them. Some variables are of course not quantifiable (land inheritance systems) and others are quantifiable only with difficulty (degree to which an opinion is held), but most variables are at least in principle able to be quantified. All things being equal, the more quantification the better, but several considerations are important here. First is the time and expense required to achieve the extra quantification and to use it in analysis. Second is the ability to accurately sample and measure the variable. And third is the degree to which the extra quantification is really needed in the analysis.

Thus the researcher should consider the range of quantification necessary for his purposes. One way of thinking about this is to consider whether nominal, ordinal, or interval scales are required for recording the data. In measuring the presence of a certain weed in farmers' fields for instance, one might choose to report simply yes/no; another possibility might be to rank the amount of the weed present on a scale of 1 to 5; finally, sample areas of fields may be chosen for an actual counting of the number of weeds per square meter. The first method is obviously the easiest, but may give misleading conclusions about the importance of the particular weed. The final method is very time consuming.

Many times, results from FSR are such that statements like, "Only 13.2% of farmers use chemical fertilizer, with an average application rate of 23.7 kg of N per hectare", are in fact not actually that precise and of no more use than the statement that, "Very few farmers use fertilizers and those that do apply fairly low rates of N". But more quantitative reports are often used to secure support for further research or to convince policy makers on certain points, and in almost all cases such quantitative statements carry more weight. General observations, estimates, trends, opinions are all valuable but sometimes less effective to report; a nice table brings the message across more effectively.

But the issue remains, "What are you going to use this data for?". Excessive emphasis on quantification may draw the researcher's attention away from more important issues. In the example in the previous paragraph, it may be argued that if preliminary work in the area indicates that fertilizer use is generally low despite obvious nutrient deficiencies, it may be more useful to devote time not in trying to quantify the exact amount used but rather trying to understand who uses fertilizer and under what circumstances.

Degree of Representativeness. An important consideration in deciding what degree of specification and quantification should be sought during data collection is the possibility of achieving a truly representative sample. A variety of techniques is available for sampling in specific situations (see for instance Kearle, Ch. III, for a discussion of methods for drawing probability and non-probability samples). However, degree of representativeness is not only a problem in formal survey techniques where a random sampling method may be employed. Indeed one of the principal problems with informal techniques such as sondeos in FSR is the probability of sampling bias. Some of the problems have been identified by Chambers in his work on "development tourism", where he points out that quick visits by researchers to farming areas are often heavily biased in favor of farmers who are near towns and paved roads, part of special projects, males, elites, and high users of services and inputs. Thus the use of non-random methods to identify farmers will be in danger of producing very misleading reports unless researchers make a considerable effort to overcome these biases.

Representativeness is also important in on-farm experimetnation. The validity of the results from experimentation is potentially higher than other data collection methods but only if efforts are made to test the experimental variables in fields of farmers that represent the variability of farmers in the area and under management that represents farmers' management.

Finally, an important issue in representativeness is the confidence interval that is placed on measurement of specific variables. Again quantitative estimates of his interval may be useful for communication of information to others even though it may not change the degree of confidence researchers themselves have on a specific variable. Quantitative estimates of confidence intervals of course depend on the sample size in relation to the variability in the area. Two principles are however important in choosing sample size. First, variability is specific for a given variable and hence different sample size may give equal confidence in the measurement of a variable. Second, confidence intervals are often fixed arbitrarily (e.g. 95%) in traditional statistical methods and this may not bear any realationship to the economics consequences of wrong decisions based on the information available. Hence confidence intervals should vary for different variables depending on their economic consequences. For example, the decision to launch a full scale extension program based on information from an FSR program may require fairly high confidence in the information. The decision to include a perticular variable in an experimental program may require less confidence on the part of researchers.

Characteristics of the Situation in which FSR is to be Implemented

The design of a data or information generating process is a function of the specific research situation. This research situation can be characterized by features of a) the research area, b) the research project.

Characteristics of the Study Area

FSR is by definition farmer oriented and hence focused on specific groups of farmers in a given area. These farmers operate a given farming system which reflects the natural and socio-economic environment of the area. The resulting farming system varies substantially in degree of complexity. A complex farming system typically includes a number of different enterprises, including crops (often intercropped), non-farm and livestock enterprises, and in many cases more than one management strategy for a given enterprise - such as use of two or more varieties or planting dates for a given crop enterprise. This complexity is often greatest for small farmers who produce largely for subsistence purposes with limited capital resources and with substantial weather-induced risk (Byerlee). Understanding such a farming system and measuring data on specific variables will often be more difficult than in a simple or monocrop situation. With substantial year to year variability, caution is also needed in interpreting information obtained for one cropping season. Moreover because of the wide range of activities in the farming system, it may be dificult to efficiently narrow down to the key variables. To overcome this problem in CIMMYT, we have proposed that FSR initially focus on a predetermined crop in the system chosen because it is a major user of the farmers' resources (Collinson).

Nonetheless, a more complex farming system implies a greater investment of time and resources to understand the system and identify the variables for experimentation.

The complexity of the study area is also determined by the variability of the farming system within the area. Some researchers argue that an effort be made early in the research process to group farmers into relatively homogeneous groups or recommendation domains. The collection of data would then initially focus on one of these groups. This is a desirable strategy especially when the classification of farmers can be made on the basis of prior information. However, in many cases variability in an area is due to a number of different environmental factors and a good deal of information must be generated in order to be able to decide what is the really important variability from the point of view of designing improved technologies and what is the best dividing line between groups of farmers[1/]. It is our experience that in a heterogeneous study area, quantitative data is often useful in understanding how variation across the area affects farmers' practices.

Characteristics of the farmer also affect the choice of data collection methods. Level of education and familiarity with local or standard units of measure are of course important in making decisions about direct observation versus farmers' estimation of variables such as yield, area and labor inputs per unit of area. Also the differences in languages in a study area and

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[1/] For example in areas with substantial variability in farm size, information on variability of production practices by farm size is often needed to be able to decide if stratification by farm size is needed, and if so, at what farm size(s) is this division(s) made.

and especially between farmers and researchers affects but does not exclude the use of unstructured methods which depend on direct researcher-farmer dialogue. Farmers' previous experiences with external contacts, especially government officials may also be a factor in choice of data collection methods. Where there is substantial suspicion of outsiders, use of methods that do not depend on written recording of information may be more appropriate.

Ease of travel in the study area is another factor affecting decisions on data collection. Where good road systems exist, it may be quite cheap to make field observations on randomly selected fields on a frequent visit basis or to use area sampling methods. At the other extreme, very poor communications in the area may make random selection of farmers very difficult even if a cluster sampling approach is used.

Finally, the availability of existing secondary data will be an important factor in designing the data collection process. Available secondary data, including previous surveys and experimentation in the area, often helps to focus the data collection more quickly. Secondary information such as lists of farmers is also important in deciding on a sampling method.

Characteristics of the Research Project

FSR projects vary substantially in the available human and financial resources, the place of FSR in the overall research institution and the working environment provided for individual researchers. Probably the most important factor in this mix are the available human resources in the form of trained and experienced researchers. In many cases FSR is introduced precisely because researchers have had little experience in working directly with farmers to solve specific problems. Hence the design of the data collection process must be based on fairly simple methods which can be used by less experienced researchers. In particular, few agricultural research systems employ social scientists and most FSR projects must begin with limited social science capability. Typically then an FSR project must "think small" and adopt a long run strategy of building up the capability of the researchers in data collection methods through informal on-the-job-training and possibly formal training courses.

The logistical support of a project will also be a factor in designing the data collection process. Clearly support in the form of transportation to move about the study area is almost an essential prerequisite for a successful FSR program whatever methods are used. In other cases, the method may be chosen depending on available support, For example, few projects have access to efficient data processing facilities so that collection of specific, quantitative data should be restricted to a minimum. In many cases collection of large amounts of data without adequate facilities for data processing, is a major bottleneck in developing an effective FSR project.

The institutional structure in which FSR is situated has a number of implications for the design of the process. If FSR is imposed, for example with external support, the project will need to demonstrate early payoffs in order to attempt to build up internal support and continuity for the project. This further reinforces the need to design the data collection systems to efficiently focus on a few high priority problems that promise immediate solution. Finally the incentive structure facing individual researchers is often a limiting factor in the success of FSR. Researchers require incentives to direct their efforts to farmer problems rather than traditional disciplinary oriented research efforts. And to effectively work on farmer problems, requires substantial field work off the research station. That is, incentives are needed (or at least removal of disincentives) to ensure that researchers' travel and lodging costs for field work are adequately covered. Since all <u>effective</u> data collection methods require field participation by the researchers, there is really no alternative to the design of an appropriate incentive system to encourage this participation.

CIMMYT Experiences in Designing Data Collection Systems

Evolution of the CIMMYT Methodology

CIMMYT first became actively involved in OFR programs in about 1975. At that time a concerted effort was made to switch attention from *ex poste* adoption studies (Perrin and Winkelmann (1976)) to *ex ante* involvement of economists in designing technologies. The data collection system employed initially emphasized a one-visit formal survey to obtain information on practices and problems in the target crop (e.g. Mamafiya; Moscardi; Perrin). The survey design and implementation in this initial work was largely the province of the economist.

In the next stage, an informal presurvey was introduced (Collinson). The purpose of this presurvey was largely to help orient the formal survey by improving researchers' familiarity with the study area and enable better design of the questionnaire and sampling techniques. The method involved researchers conducting some farmer interviews fairly informally as they traveled through the study area over a short period of days. Researchers involved in these presurveys soon recognized the advantages of the informal interviews conducted by researchers themselves as a means for obtaining a rapid understanding of the system. Accordingly, the role of the presurvey or exploratory survey as it was renamed, was elevated in the hierarchy of data collection methods. Primary importance was then attached to the exploratory survey and the formal survey became the mechanism for verifying specific information obtained in the exploratory survey.

The current methodology comprises an integrated data collection system including secondary data analysis and exploratory surveys, a formal survey and experiments (Byerlee, Collinson *et al*). The general elements of this methodology are shown in Figure ___. In this approach the major strategy in efficient data collection is the sequential process of rapidly narrowing down to focus on the most important information needed for solving a very few high priority farmer problems. The characteristics of each data collection method are shown on Table __. As the information is narrowed down, information collected tends to be based more on observation with more structured specific methods with higher level of quantification and representativeness.

This general approach is, of course, evolving over time as new experiences are accumulated and must be modified to suit the characteristics of each research situation. In particular, there has been considerable debate as to whether a formal survey is really needed. On the one hand, we have found that agronomists are quite interested in participating in the exploratory survey whereas they had previously had less interest in the formal surveys. Hence, the need for quantitative information to convince agronomists on experimental content has largely been negated. Secondly, a number of experiences where we have conducted a formal survey following an exploratory survey have indicated that the formal survey provided little new information. In three cases, we conducted an exploratory survey developed a questionnaire and then noted what we expected the responses to be. In one case, in a fairly homogeneous area we predicted accurately the outcome of the most important questions. In a second case where there was some heterogeneity to ease of access to villages, we found that we had considerably overestimated the use of improved maize technology in the exploratory survey because we had emphasized more accessible villages. However, information from the formal survey did no change our conclusions on experimental content. In the third case where there was a great deal of variability by farm size and agro-climatic characteristics, the information from the formal survey on some important variables was quite important in understanding how these factors affected farmers' practices and in dividing farmers into groups for the purpose of on-farm experiments.

Recent experiences reflect efforts to further improve the efficiency of data collection systems and tailor them more closely to the specific research situation at hand. We briefly describe three of these experiences below:

Production Research Program in Ecuador

In Ecuador, the national agricultural research institute (INIAP) has a separate program which is responsible for on-farm research. Members of the program are stationed in ten different areas of the country. In each of the areas work is carried out on the principal crop or crop mixture which is grown by small farmers. When work is integrated in a new area an informal survey is carried out by members of the various crop breeding programs and support departments which will collaborate on trials. They visit the area, talk to farmers, visit fields, and discuss issues with some officials. This generally takes one to two weeks. After this, a formal survey is carried out which emphasizes qualitative data, in order to further refine knowledge of the area and select questions to be addressed in trials. The enumerators for these surveys are always INIAP employees, and include the agronomists from the on-farm research program who will be stationed in the area, the technicians (high school degree) who will be assisting them, and other members of experiment station programs and departments who will be collaborating in the research. The results are analyzed and reported as quickly as possible. The sample size is generally small enough (80-150) and the questionnaire straightforward enought that the analysis can be done by hand, with the help of a calculator. As the program is a new one, researchers have found it useful to have these survey results to present to the extension service of the Ministry of Agriculture, the Rural Development Secretariat, and other institutions with whom they must collaborate, as well as for use by station scientists.

Researchers plant between ten and thirty on-farm trials in a given area each year. Information is derived not only from observations of the trials but from conversations with farmer collaborators as well. In one of the areas, a field book is used which records a wide range of information about collaborators and their management practices. The questions in the field book are redesigned each year as certain problems are resolved and other appear. The question in the field book serve as a guide, and are generally not administered formally to the collaborator. The field book is rather filled in gradually during the course of the season, based on informal conversations between the researcher and farmer. As considerable care is practiced in trying to plant trials with a representative sample of farmers, the group of collaborators serve in same sense as an on-going panel for the study of various problems.

On-farm research is a dynamic process. As time goes on, trial results lead to recommendations for farmers, but other results, combined with observations and conversations with farmers, lead to further hypotheses. Some of these can be tested through trials, others through informal surveys or questioning, and some require formal survey work. In one of the research areas, maize and beans were the original focus of work. After four years, recommendations had been produced for an early-maturing maize variety that was finding high acceptance among farmers, and attention shifted to other crops that could be grown in rotation or association with the new maize. As the original survey had not dealt with these crops, it was thought useful to design a small survey whose results could help guide work in future seasons. Because the researchers had considerable experience in the area, they were able to select a series of nine communities which were representative of the major variations in the research area for the survey. As they well well known in most of these communities it was easy to obtain, or construct, lists of farmers, make a random selection of 10 farmers for each site, and carry out a small survey directed at cropping patterns. Collaboration was excellent because farmers understood by this time the nature of the work and had been its results. The survey was carried out by the staff who were working in the area, plus two members of the INIAP agricultural economics program, and it was completed, analyzed, and ready for use in trial planting within four months.

Ghanaian Grains Development Project

On-farm research on maize and cowpeas has been conducted in Ghana under a CIDA/CIMMYT agreement with two Ghanaian institutions - the Crop Research Institute and the Grains and Legumes Development Board. The farmer has responsibility for most of the on-station research, especially breeding work while the latter has conducted most of the on-farm research.

Prior to the project, some on-farm experimentation had been done in Ghana especially on fertilizer trials in maize and verification and demonstration of improved maize technologies. However, these trials were not a part of a sequential data collection system and in some cases, especially in spacing thinning, the technology emerging was inconsistent with a farmers' constraint of a seasonal labor shortage. Farm level surveys in Ghana had been conducted largely by universities and had emphasized the traditional farm management approaches of collecting general input-output information and were not aimed at solving specific farmer problems.

The current project has developed a sequential data collection system. Limitations of research resources to one economist less than full time has prevented application of the full methodology. The exploratory survey has been the basic data collection method for identifying constraints and planning on-farm experiments. These exploratory surveys have been conducted at the rate of two a year in each of the major ecological regions in which maize is grown. On-farm experiments have been planted since the first year based on whatever information was available to help choose variables for experimentation. Information from the exploratory surveys have been incorporated and has been important in more clearly specifying variables for experimentation and in evaluating results. The data from the exploratory survey is complemented during the verification/demonstration experiments when some specific quantitative information is collected from collaborating farmers on practices, inputs and outputs during the season. A special form is provided for the technician to fill in information as a farmer completes a specific operation.

One structured formal survey has been conducted following an exploratory survey in order to verify information. However this has not been extended to other regions for two reasons. First, the researchers' time spent in obtaining further information by the formal survey in this one region was about five weeks which had an opportunity cost of exploratory surveys in two other regions. This does not include the time needed for data processing which has been delayed because of lack of a computer software program. Second, the formal survey largely verified and strengthened the results of the exploratory survey and provided little or no new information that would change the design of the on-farm experiments planted in the area.

The exploratory surveys have built-up a useful base of information on farming systems and maize production practices in various ecological regions. In most cases they provide a good deal more description and understanding of the farming systems and major factors influencing farmers' practices than had been the case from earlier farm management surveys. Indeed, the exploratory surveys have also been quite successful in getting reliable estimates of input-output data for construction of farm and enterprise budgets. These are being confirmed by the information obtained from farmers cooperating in the on-farm experiments.

As the project approaches the point at which recommendations can confidently be made to farmers, the major bottleneck to increased productivity will be policy issues relating to the allocation of foreign exchange and distribution of inputs. Accordingly, consideration is being given to more formal surveys focusing on specific information for policy purposes. It is envisioned that these surveys will only collect information on a maximum of

40 variables relating to specific policy questions[1/].

The project has recently purchased a micro-computer which will be used to process data from the formal surveys and from the on-farm experiments.

Wheat in the Yaqui Valley, Mexico

CIMMYT and the Mexican national research organization, INIA, have worked for over thirty years on wheat research in the Yaqui Valley. In fact it was in this area that the high yielding semi-dwarf wheat varieties were developed and first released. CIMMYT and INIA have had a committment to on-farm research, but without the involvement of economists and with no systematic effort to describe and understand farmer circumstances. A survey was therefore designed to obtain at relatively low cost a broad description and understanding of wheat production practices in the area. It focused on specific information on the weed problem, the major factor limiting production in wheat in the area.

A two stage semi-formal sampling procedure was used. The first stage was irrigation blocks (400 ha each) which were sampled randomly. In the second stage we took all farmers in the block if there were less than 5 farmers with wheat in that block. If there were more than five farmers in a block, we chose farmers according to convenience in locating them, provided that a) we seemed

[1/] In the case of fertilizer distribution, a major problem, data will focus on which farmers are obtaining access to fertilizer, farmers knowledge and perception of the benefits from fertilizer compared to actual use, past experience with fertilizer use and factors such as cropping intensity that are associated with natural fertility. This information combined with data from experiments on fertilizer will then provide guidance to an improved distribution system.

to be getting a reasonable cross-section of good, intermediate and poor fields as determined by visual inspection of all fields in the block and b) we also obtained a representation of land tenure types in that block (i.e. private farmers - small and large, individual ejidatarios and collective ejidos).

Unstructured interviews usually including senior researchers were conducted as informally as possible to obtain the following information (not necessarily in a fixed sequence).

a) Specific data on 35 key factural variables - largely specific practices for a specific field (chosen at random among the farmers' fields) but also including cropping system, land tenure, credit source and machinery availability. The choice of the 35 key variables was based on the first two days' work where an attempt was made to visit different types of farmers and different parts of the study area.

b) More indepth conversations about specific themes, depending on the practices, experiences and interest of the farmer. On average, we treated 3-4 themes in this way in each interview.

c) Observations were made on each selected field with particular emphasis on weed problems. The types of weeds growing in each field were noted and a subjective estimate of percent yield loss to grassy weeds was made. Eye estimates of yield loss were calibrated with the aid of agronomists experienced in weed problems in the area. Only a few minutes was required for each observation.

In addition to the "random" sample, we also talked informally to other farmers we met as well as extension agents, bank officials, etc. as would be done in an exploratory survey. However, data on the 35 key variables were not recorded in these interviews.

Information was recorded after the interview on three precoded forms - a closed form for the key variables, an open form for the themes treated in depth and a closed form for any prices and costs mentioned by the farmer. Initially we did not take notes during the interview but soon found that the complexity of the system required us to note the quantitative data (e.g. date of planting, quantity and type of fertilizer). These data were recorded in a notebook.

Running tabulations of the 35 key variables were made during the survey. Simple and cross-tabulations were set up to check the sample and test hypotheses. In some cases this led to new hypotheses and areas for further questioning. Other information provided by the farmer - opinions, experiences, etc - was transferred to a notebook organized by theme as in an exploratory survey. This served as a basis for writing the report.

The method had several advantages. It was an efficient use of researchers' time since field work for a sample of 100 farmers involved three weeks of senior researchers' time. (An exploratory survey would have required at least two weeks in this complex area.) Moreover, the preliminary analysis and write-up was completed in less than a week because tabulations were already done during the survey and relatively few variables were tabulated. The quantitative information on the key variables was also valuable in several respects. First, cross-tabulation was important in understanding the substantial variability that existed in the area. Secondly, quantitative data from the field observations correlated very strongly with farmer practices and substitued for experimentation - some of which involving rotations would be expensive and time consuming. Finally, input distribution problems through the official bank were uncovered which can be clearly portrayed by cross-tabulations of input use by credit source.

There are some possible problems with the approach. The identification of key variables stabilized rapidly in the first two days but some changes were still made after one week of field work. Also there is a tendency for researchers to trade-off indepth informal interviews to shorter more formal interviews to obtain information on key variables and meet a daily sample "quota". Also with random sampling some time is lost by senior researchers in locating farmers. These problems can possibly be reduced by having a separate enumerator team to expand sample size for the key variables.

Work will continue in 1981/82 with emphasis on experimentation. The selection of fields for experiments will be based on the farmers selected for the survey taking into account the practices they were using on wheat production. Informal survey methods will be used to continue to accumulate information on wheat production practices, using collaborating farmers as sources.

Conclusions

We have argued in this paper that FSR has some specific requirements that need to be consider in the design of a data collection system Firstly, FSR has or should have well-defined objectives - the generation of quite specific information for specific users. There is a need then to identify clearly the user, the important variables for that user and then focus research efforts on their measurement. We believe the sequencing of information gathering from a broad understanding of the farming system down to the important variables is an efficient method that could be more widely employed in FSR. As the range of important variables is narrowed, more information can be obtained on each variable through more structured and specific surveys, field observations or experiments. Secondly, the researchers themselves need to be actively involved in the data collection. Especially in the initial stages, researchers from various disciplines must dialogue with farmers and become familiar at first hand with the study area. The unstructured non-specific interview conducted by researchers themselves is an efficient method of obtaining a rapid understanding of existing farming systems and practices. Researchers involved in this type of interview need to develop a better conceptual framework than is currently provided by farm management methods which largely emphasize input-output type data. A systems' framework which interrelates the farmers' objectives and resource constraints with his natural and socio-economic environment, provides a more flexible model for organizing information. Once the data collection moves to measurement of specific variables, the participation of the researchers is less crucial, especially where a large sample is to be employed to provide narrow confidence limits on a variable. However, the presence of the researchers in the field and the use of participant observation methods ensures that researchers are continually broadening and deepening their understanding of the farming situation developing new hypotheses and defining problems for future work.

Thirdly, the quantification of variables with statistically determined confidence levels should be severely restricted in FSR programs to key variables. In our experience, this type of quantification is most useful in two types of situations. In complex areas with substantial heterogeneity in several dimensions (e.g. highly variable farm size and soil type), quantification and formal testing of hypotheses is often useful to give researchers a clearer picture of this variability and how it affects farmers' practices. Secondly, quantification is often necessary to convincingly communicate information to the users - farmers, experiment station researchers and policy makers. But in each of these cases the range of variables for which quantification is needed is quite small. In most cases, a formal structured surveys with a one page questionnaire and 30 variables will be quite sufficient. The remaining 300 plus variables often collected in a several page questionnaire are usually at best only marginally useful in strengthening the value of information finally communicated to the user.

Fourth, we should not confuse quantification with representativeness of data. The principal problem with unstructured exploratory surveys is the lack of a mechanism for ensuring that the data obtained is representative of farmers in the area. Since inter-village variation is often much more important than intra-village variation, a sampling method in which at least the first stage sampling unit - the village - is chosen at random, could be