

Monitoring Farmers' Practices and Fields as a Continuing Activity in On-Farm Research for Evolving Cropping Systems

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ABSTRACT. Any program of research, whether conducted in the experiment station or in farmers' fields, needs to monitor farmers' practices and fields continuously in the target research area. Monitoring is a means of updating research priorities – including those related to the long-term sustainability of cropping systems – and of documenting farmers' adoption of technologies developed through research. This paper describes the information that can be derived from continuous monitoring surveys, gives examples of how that information can be used in research systems to improve the efficiency of research, and discusses the resources required to conduct monitoring surveys and some methodological issues involved in their implementation.

Farming systems research (FSR) methods include several steps from diagnosis to experimentation to technology assessment and adoption studies (e.g., Simmonds 1986). In most FSR programs, an initial diagnostic survey is conducted as a "one-shot" exercise at the beginning of the research process (Norman 1980); monitoring and adoption studies, if carried out at all, take place several years after the initial survey. This paper argues that any research program, whether on the experiment station or farmers' fields, needs to monitor farmers' practices and fields continuously in the target research area as a means of updating research priorities (including those related to long-term sustainability of the system) and documenting farmers' adoption of new technologies developed by the research system. This information is especially important for guiding research on rapidly evolving farming systems such as the intensive irrigated systems of Asia. The paper describes several kinds of information derived from continuous monitoring surveys, provides examples of how that information can be used in research systems, and concludes with a discussion of the resource requirements and methodological issues that arise in implementing monitoring surveys.

USES OF INFORMATION FROM MONITORING SURVEYS

Monitoring surveys normally involve surveying a sample of farmers at least once a year to obtain information over time on key farmer practices and, in some cases, information over time on soil physical or chemical properties or pest populations. Information from these surveys can have three major uses: continuous diagnosis, monitoring the adoption of technology, and monitoring the sustainability of the farming system.

Continuous diagnosis

Few FSR programs have implemented formal surveys to provide quantitative information over time, even though some researchers have argued that diagnosis is an ongoing process in FSR (Tripp 1989). Where farming systems are evolving rapidly, as in Asia's irrigated areas, information from the initial diagnosis quickly becomes outdated (Maxwell 1986). This rapid evolution of farming systems results from a number of factors characteristic of these systems (Byerlee 1987):

1. Changes in the economic and technological environment that stimulate rapid adoption of new cropping systems. The dramatic spread of the rice-wheat, soybean-wheat and cotton-wheat double-cropping systems over millions of hectares in South Asia over the past two decades is evidence of these changes.
2. The rapid adoption of new technologies that have important implications for the farming system as a whole. For example, the adoption of a new early-maturing Basmati rice variety on 70% of the rice area in the Punjab of Pakistan from 1986 to 1988 had important implications for land preparation and planting date for the wheat crop that followed rice (Sharif et al., in press).
3. Changes in the quality of the resource base, such as levels of soil fertility, salinity and organic matter or the depth of the water table. (Monitoring these types of changes is similar to monitoring factors linked to the sustainability of farming systems.
4. Changes in pest populations, such as a new weed spectrum, perhaps as a result of changes in cropping patterns or practices in (1). For example, the weed *Phalaris minor* has spread considerably since 1975 in irrigated wheat in northwestern India and Pakistan. In Mindanao, Philippines, new weed spectra were observed after only two years of chemical weed control on maize (Oliva et al. 1990).

Given these types of changes, researchers need to continuously update research priorities for on-farm adaptive research as well as for applied research on experiment stations.

Monitoring adoption of technology

Asian research and extension systems (public and private) now continuously generate new technologies, which farmers continuously adopt. For example, new

wheat varieties are released yearly in major wheat-based systems, partly to ensure continued resistance to evolving pathogens. It is important to monitor the adoption of technology to provide feedback to research administrators on the successes or deficiencies of research programs. Such information is increasingly necessary to researchers who must demonstrate the impact of their work and justify research expenditures.

Monitoring sustainability of the system

Concern about sustainability of the intensive irrigated systems of Asia obliges us to develop methods for monitoring sustainability, especially its two critical elements – changes over time in productivity and in the quality of the resource base. Monitoring changes in productivity, which is defined here as total factor productivity (TFP), requires fairly comprehensive farm management information on inputs and outputs. Widely used by economists, TFP is a measure of changes in output in relation to changes in an index of all inputs. In some cases, partial productivity measures based on changes in key inputs may alert us to sustainability problems (e.g., Byerlee and Siddiq 1990).

Determining changes in the quality of the resource base may involve measures of changes in soil variables, the quality of irrigation water, pest populations and other factors over the long term (e.g., 10 years or longer). An additional dimension of sustainability, related to stability of the farming system, is the breadth of genetic diversity represented by the varieties farmers grow. At present, little information is available for assessing the long-term sustainability of the quality of the resource base or varietal diversity in specific farming systems.

EXAMPLES OF FARMER AND FIELD MONITORING

Farmer and field monitoring surveys conducted over a number of years have provided or are intended to provide valuable information for research systems.

Date of planting and varietal adoption in Pakistan's irrigated systems

Since the advent of the Green Revolution in the 1960s, cropping has intensified steadily in Pakistan's Punjab as farmers have adopted earlier maturing varieties of wheat, rice and cotton and as supplies of irrigation water have improved. Increasingly, wheat forms part of a double-cropping pattern with rice or cotton. Although no survey has been undertaken to monitor wheat planting dates in the rice-wheat or cotton-wheat systems, data on planting dates have been pieced together from surveys done at different periods by different agencies (Fig. 1). Wheat planted after rice and cotton tends to be planted well after the optimum date (mid-November).

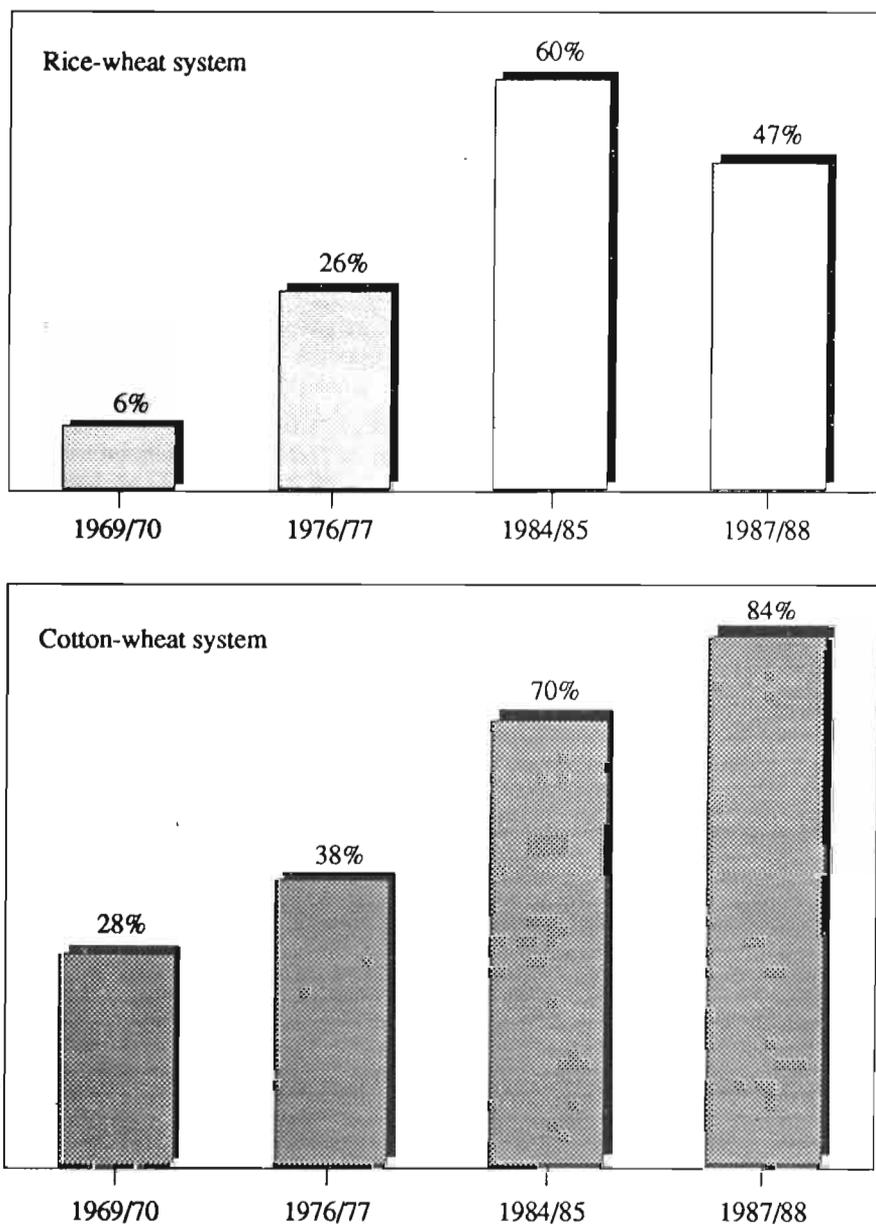


Fig. 1. Percentage of wheat planted late (after 1 December) in the Punjab of Pakistan. Source: S. Bashiruddin (pers. comm.).

The trend toward late planting of wheat is quite striking: by the late 1980s, late planting was the norm in much of the Punjab.

Until recently, wheat breeders concentrated on developing varieties for optimal planting dates. Before 1983, less than 20% of all varieties released were recommended for late planting. Data from farm surveys in the 1980s showing that over half of the wheat area was planted late helped convince breeders to give greater emphasis to varieties for late planting and to seek varieties that performed well over a range of planting dates, since farmers normally grew only one variety (Byerlee et al. 1987).

There is a clear need to monitor wheat planting dates to set breeding priorities. The planting date for wheat in the rice-wheat and cotton-wheat systems depends on several factors: the date that the previous crop was planted, the variety of the previous crop and the turnaround time from the previous crop to wheat sowing. In the case of cotton, the management of the crop and the price received by farmers for it are also important determinants of wheat planting dates (Fig. 2). Hence, monitoring planting dates to set wheat breeding priorities also requires continuous monitoring of other key variables in the cropping system, such as rice and cotton varieties and prices.

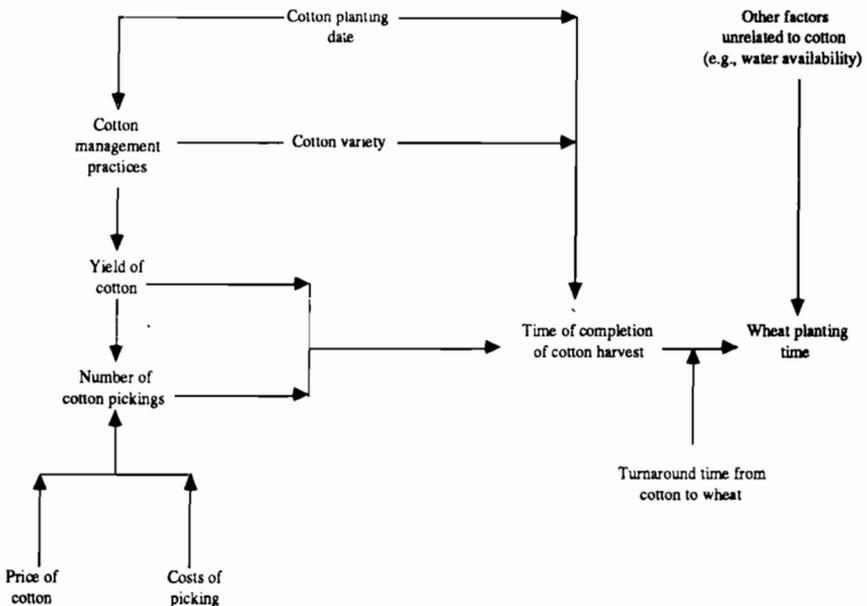


Fig. 2. Schematic representation of factors affecting wheat planting time in cotton-wheat rotation, Punjab, Pakistan.

Monitoring adoption of crop management practices in Mexico

Wheat in northwestern Mexico is grown under irrigation in a system that includes cotton and oilseeds. The major research station in northwestern Mexico conducts research on crop management (CMR) for wheat and regularly updates recommendations for its production. In 1989 a comprehensive evaluation of the impact of CMR was undertaken (Traxler 1990). Fortunately, a series of surveys of a panel of 100 farmers undertaken since 1981 provided a detailed description of changes in farmers' practices (Table 1). This information was the basis for identifying which products of the CMR program made an impact in farmers' fields. A comprehensive review of changes in farmers' practices in relation to changes in research recommendations concluded that two practices – ridge planting and integrated pest management for aphids – were adopted widely and provided good returns to farmers and to the research system. Aside from these two practices, however, much of the CMR program had had little impact in farmers' fields. In fact, farmers' practices for fertilizer doses and seed rates went against those recommended by the program.

Table 1. Summary of changes in crop management practices, irrigated wheat, Yaqui Valley, Mexico, 1981-89.

Practice	Year				Significance of statistic *
	1981	1982	1987	1989	
Type of wheat					
Planting durum variety (%)	19	19	44	44	***
Land preparation					
Subsoiling clay soils (%)	32	na	36	23	ns
Planting method					
Using ridge method (%)	8	5	37	33	
Using dry planting (%)	60	60	17	16	***
Seeding rate					
Ridge method (kg/ha)	76	75	122	125	***
Traditional method (kg/ha)	163	156	175	175	***
Planting date					
Median date	Dec 5	Dec 9	Dec 10	Dec 6	ns
Fertilizer use					
Nitrogen (kg/ha)	176	194	218	230	***
Phosphorus (% applying)	59	56	83	78	***
Insect control					
Applying insecticide (%)	82	64	27	56	***

* Using chi-square or t-test as appropriate to test difference in use of practice over years.

ns = not significant,

*** = significant at the 1% level.

This feedback can be especially valuable in monitoring research impacts. However, data on farmers' practices over time are needed for this kind of review, especially in the case of "continuous" practices such as fertilizer dose, which farmers have difficulty recalling.

Monitoring system sustainability

I am unaware of any formal efforts to comprehensively monitor the sustainability of a system over time, including measures of TFP and of changes in the quality of the resource base. But because of the concern that productivity in the rice-wheat system in South Asia may be declining and because of the need to identify sustainability problems at an early stage, such an effort is planned for several key sites in the rice-wheat system. The monitoring system will measure TFP through the collection of standard farm management data. At the same time, information on variables reflecting technical change (e.g., variety, new inputs) will be collected. Researchers also plan to monitor a sample of fields to measure changes in soil physical properties, soil fertility and disease problems (Harrington 1990).

Information from these surveys might be used in two ways to measure sustainability. One way would measure sustainability directly through an analysis of changes in TFP in relation to changes in the quality of the resource base. There are four possible combinations of outcomes of this analysis.

	Trend in TFP:	
	- ve	+ ve
Trend in resource quality		
- ve	1	2
+ ve	3	4

Situation 1 clearly indicates lack of sustainability, while situation 4 indicates a sustainable system. Situation 2 is ambiguous and involves tradeoffs between resource quality and growth in productivity. Situation 3 is an unlikely event.

Another use is for estimating a production function over time and relating shifts in the production functions to changes in variables that measure resource quality and variables that measure technical change (Harrington 1990).

This kind of monitoring will be more data intensive and expensive than the other examples mentioned earlier. However, given that Asia's intensive irrigated cropping systems are essential to the welfare of hundreds of millions of poor people, I see no alternative to initiating a concentrated effort to monitor their sustainability

so as to identify emerging problems at an early stage and to design appropriate interventions to arrest any negative trends observed.

METHODOLOGICAL ISSUES IN DESIGNING A FARMER AND FIELD MONITORING SYSTEM

Continuous monitoring involves significant cost outlays (see the next section of this paper). A monitoring system must provide the minimum necessary information of sufficient quality to satisfy researchers' objectives. The major methodological issues that need to be considered in designing a monitoring system are the variables to be collected, the frequency of the survey, the sample size and method.

Variables to be collected

Several categories of variables to be collected may involve different costs and levels of difficulty.

Key farmers' practices. Obtaining data on farmers' practices usually involves gathering a minimum of information on variety sown, planting date, crop rotation and fertilizer and pesticides applied. Many other variables, including tillage practices, irrigation practices and turnaround time might be added depending on the system under study. These data are the cheapest and easiest to collect.

Inputs and outputs. If a full farm management accounting is required (e.g., to measure changes in TFP), data on machinery, labor costs and crop yield will be required. Such data are more difficult to collect in single-visit surveys because farmers find it difficult to recall precise labor inputs. Moreover, these data will be most useful if collected at the field level (versus taking the farm-level approach common to farm management surveys). Researchers must also decide whether to record yield by taking farmers' estimates or using the crop-cut method. Crop-cutting provides an opportunity to measure plant density and other yield components; and problems (reviewed in Poate 1988) are likely to be fewer in irrigated systems.

Quality of the resource base. At the moment, researchers have little experience with monitoring variables to measure changes in resource quality and sustainability. At the very least, regular soil testing over time is needed. While not inherently difficult to obtain, reliable soil test data require a well-conceived field sampling design and good soil laboratories.

Pest populations. Again, there is relatively little experience with monitoring this type of variable over time. Costs of estimating pest populations generally

depend on whether a subjective scoring method or objective quantification is used (Byerlee et al., in press). Subjective scoring requires careful calibration among researchers.

Frequency of monitoring

A key question in any monitoring system is the frequency of visits to the farmers and their fields. Frequency is influenced by three considerations:

1. Frequent visits (more than once per crop cycle) can be expensive. It is desirable, however, to collect a minimum data set for each major crop in the cropping pattern on an annual basis. Less frequent monitoring can still provide valuable information (for example, see Traxler 1990); without annual data, however, it will often be difficult to distinguish longer term trends of interest in setting research priorities from short-term fluctuations caused by variability in weather or the economic environment.
2. Not all variables need to be collected on every visit. For example, if one objective of the monitoring is to determine trends in soil organic matter levels, soil sampling at intervals of several years may be sufficient.
3. Given limited resources, usually there is a tradeoff between in-depth monitoring of a small sample of farmers and/or fields and less frequent visits to a larger sample. Although both strategies may be combined, virtually no data are available on trends in farmers' practices and fields and hence I favor the latter strategy.

Sampling issues

Given the objectives of monitoring, the field rather than the farmer should be the sampling unit. Certainly, monitoring sustainability variables such as soil fertility and pest populations has little meaning at the farm level. A new sample may be selected every year or the same fields may be revisited over time. Repeated visits to the same farmer and field have these advantages:

- Changes in practices and resource quality can be tracked more accurately over time through pair-wise comparisons at two points in time for the same field.
- Once the initial cost of constructing a sample frame, selecting a sample and contacting the farmers has been made, the cost of repeated surveys is greatly reduced.
- By following the same sample of farmers, changes in practices may, in some cases, be related to farmers' management skills and "learning-by-doing."

At the same time, some precautions should be taken in repeated sampling:

- If the objective is to monitor a major cropping pattern such as the rice-wheat rotation, a sufficient number of fields should be selected to allow "dropouts" in some future visits because of a change in cropping pattern in some fields.

- The location of fields and farmers should be documented carefully (preferably by mapping) so that when research staff change, new staff can readily locate the same fields and farmers.
- Since the sample design is intended to provide information over many years, it is important that considerable thought be invested at the beginning in ensuring that sample size, representativeness, stratification, etc. are adequate to meet the objectives of the monitoring exercise.

As for any survey, sample size will be guided by cost considerations and the heterogeneity of the system under study. The experience of the International Maize and Wheat Improvement Center (CIMMYT) would suggest that, even for a single cropping system, a sample of less than 100 will often be inadequate once within-system heterogeneity is considered (e.g., soil type, farm size, access to irrigation) and dropouts are allowed for. In most cases, it is better to monitor one major system well, rather than try to cover all systems within the domain of the research program.

COST CONSIDERATIONS

The major cost consideration in designing a monitoring system will be the resources available for travel and per diem costs to visit farmers' fields. Each research program will have its own cost considerations, but some general guidelines can be identified.

First, monitoring must be considered a priority activity. Too many research systems operate in an information vacuum that reduces the effectiveness of costly experimental programs. FSR practitioners must argue forcefully for greater financial support for off-station work. At present, priority seems to be given to establishing new stations and programs rather than to improving the effectiveness of already established programs. If a research program is effective, the results from monitoring farmers' adoption of recommended practices should help justify research budgets.

Second, most FSR programs and many on-station programs periodically conduct *ad hoc* surveys, but results are not often comparable across surveys. A well-developed monitoring system could substitute for *ad hoc* surveys and at the same time provide more comprehensive and consistent information to various users.

Finally, agencies outside the research system frequently conduct annual surveys, such as the crop-cutting surveys of the crop reporting services in India and Pakistan and India's annual cost of production surveys. However, results of these surveys are often not useful to research because they are not publicly reported or because information on key variables is not collected or quality is not good enough. Agricultural researchers, in some cases, might be able to save costs of

mounting new surveys by working with these agencies to make relevant information available in a more timely and usable manner.

In any event, even with limited resources, regular collection of a minimum data set will often be valuable, given that so few data are now available. For example, social scientists in Pakistan have undertaken a varietal monitoring survey for major crops, which has expanded into monitoring of other key practices. This relatively low-cost activity has generated information that is in high demand by researchers, research administrators and policymakers.

CONCLUSION

In much of Asia, information about changes over time in farmers' practices, cropping systems and the resource base is grossly inadequate to ensure that research programs address emerging priorities in evolving farming systems. Nor is there adequate information to monitor the impacts of research programs, especially research on crop and resource management. In a few places, such as the Indian Punjab, some farm-level data do exist, and changes in some variables can be monitored. (Even so, different agencies collect the data, which are often not available in a form that agricultural researchers can readily use.) But in most other areas, even basic information, such as the percentage area sown to different varieties over time, is unavailable. The need for this type of information is becoming especially critical in the extensive irrigated tracts of Asia, where farming systems are evolving rapidly.

In many agricultural research systems, the concern for sustainability demands knowledge of longer term trends in both farm productivity and the quality of farmers' resource base. If the efficiency of national research systems is to improve, and if those systems are to address emerging sustainability issues effectively, research systems must invest substantially in continuous monitoring of farmers' practices and fields over time in the major farming systems that are the targets of their research.

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