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DESIGN OF THE ON-FARM RESEARCH PROGRAM[1/]

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The formulation of the research program for a site coincides with the design of cropping patterns for that site and should be completed at least one month in advance of the first seeding date at the site. Normally the yearly research program is discussed at a workshop in which all researchers at the site participate. Site researchers should be given prime responsibility for the presentation of previous research results and should be encouraged to contribute their insight about the existing farming systems, the potential for increased production, and farmers' reaction to alternatives. The workshop should draw on the support of experienced cropping systems researchers and subject matter specialists in some or all of the areas of economics, entomology, weed science, water management, plant pathology, soil fertility, and planting breeding. This workshop may take about 3 days and although the research program for the site is designed before the cropping season starts, it may be useful to re-evaluate the research program after each crop and make the necessary modifications.

Cropping pattern trials

The following steps are suggested for the design of the cropping patterns to be tested at the site:

1. Decide on the land types to be studied at the site and describe each of these as precisely as possible. The team need not conduct research on all land types in their area of operation; generally by using 2 to 4 of the most important (common) land types the team can cover the vast majority of production systems at the site.

1/ For discussion at the workshop on "Methodological Issues Facing Social Scientists in Applied Crop and Farming Systems Research" April 1-3, CIMMYT, Mexico.

2. Identify variables that constrain crop production, such as fertility problems, minor element deficiencies or toxicities or the common occurence of crop pests.

3. Decide on the cropping patterns to be studied for each land type. The patterns should be carefully designed in accord with the physical and socioeconomic conditions prevailing at the site. Farmer's cropping history, climate, product value, and potential market are all important factors to be considered. For each land type the research team should limit itself to 3 or 4 cropping patterns. These patterns may be the same for different land types. In fact it is desirable that the performance of one or more patterns can be compared between land types.

4. Each cropping pattern needs to be assigned a management technology. As the research team considers different alternatives it must evaluate the expected response and the cost involved for each alternative. After the design of the cropping pattern a simple cost-and-return analysis must be conducted. The factors should not be taken lightly as it has been estimated that to decide on varieties, tillage methods, planting methods, pest management, fertilizer additions, weed control methods, and harvest methods in addition to the timing of all operations, more than 30 decisions need to be made for a two-crop cropping pattern.

During the first year the component technology chosen for the cropping patterns will depend primarily on information from the environmental description and previous research at the site and in similar sites. Over time more information on component technology will become available from research at the site and will increasingly form the basis for decision making about the component technology levels to be used for the cropping patterns.

CROPPING SYSTEMS TESTING

Cropping patterns and their management are tested in farmers' fields to verify the assumptions made in the cropping systems research process, particularly those at the design stage. The assumptions are:

1. The proposed cropping system is biologically suited to an important physical environmental complex of the site. Yields of crops in the pattern should therefore be adequate, and biological instability should not occur.

2. The cropping pattern's requirements for economic resources, such as cash, labor, and power can be met.

3. The management components of the specified patterns are economically optimal.

4. The cropping patterns satisfy the selected economic performance criteria.

Performance criteria

The first step of the testing process is to define satisfactory performance criteria. To be useful in the context of site related research, these should not require complex computations. Nonetheless, the performance criteria must be conditioned by the factor costs prevalent at the site and the present knowledge of farmers' decision making. Because of farmers' control over on-farm resources (land, farmer's time, family labor including exchange labor, water, and farm implements), the net returns to these resources are a useful first estimate of the overall benefit derived from a cropping system by the farm enterprise. Further performance evaluation can be based on returns to cash and labor compared to their cost in the region; cash requirement compared to its availability; the required level of indebtedness compared to actual cash income of the farm; and risk as a function of yield variations (preferably the

subjective estimates of farmers) and levels of cash input.

The testing process requires more time and research personnel than the other activities described in the cropping systems research process. The monitoring of patterns and the data collection system must be both manageable and sufficiently rigorous to allow reliable estimates of the cropping pattern performance, its resource requirements, and the farmers' reactions to it.

Experimental design

The trials compare patterns that differ in crop types, the number of crops, their establishment method and time as well as their management. This makes it impossible to test patterns using replicated small plot experimental designs as the objective is to evaluate cropping patterns on the basis of their performance in the land types for which they were designed; the land types become the experimental area and fields within the land types become the plots. The experimental design used is a completely randomized design in which replicates are assumed to sample the variation of field conditions existing within the land type.

These trials often involve new crops and a change in time of operation from that used in the existing patterns in the area. For this reason the trials should be managed by farmers to evaluate the farmer's capability to manage the cropping pattern. This gives opportunities for the indentification of conflicts between the operations required for the pattern and the farmers' resource base or the climate or land qualities. Cropping patterns are tested in large (1,000 sq m) plots to allow measurement of labor and time required for the operations used in execution of the patterns. This in turn allows precise cost-and-return analysis for the patterns.

For the design of cropping pattern trials, the following general guidelines are suggested.

1. The research team should select 2 to 3 land types on which to focus its research.

2. For each land type the team should select 3 cropping patterns to be evaluated. For some patterns on some land types these patterns may be the same.

3. Each cropping pattern should be replicated in at least 5 fields in total and in at least 4 fields per land type.

The above research design should be modified as the team acquire more experience in the site. During the first year the number of patterns to be studied may be higher than 3 per land type. During the second year the number of patterns can be reduced and the number of replications can be increased to at least 5 in total and at least 4 per land type. During the third year the team should have focused in on the most promising cropping patterns. This will allow them to increase further the number of replications per pattern to at least 6 in total and at least 4 per land type. It is recommended that the research team manage from 40 to 50 cropping pattern trial fields per site.

Data Collection

The performances of experimental cropping patterns are compared to those of farmers' existing patterns, as the latter Provide the research team with a measure of the cost and productivity of production factors in the area. Methods have been developed for the collection of climate, plot, crop and operational records for experimental and farmers' cropping patterns.

The testing phase allows evaluation of the research team's ability to design improved cropping patterns on the basis of the environmental classification

employed. It allows an evaluation of the efficiency of the cropping pattern determinants as stratifying variables for design and future recommendations. In this manner the test results can lead to modifications in site description. In addition the testing of cropping patterns on the farm provides important clues to technological constraints to increased production. This could lead to complementary studies on surveys required in the area.

Component technology research

Although the major activity at a cropping systems site is the testing of improved cropping patterns, the site team must also ensure that the management specified for each of the crops in the patterns is appropriate.

As the team discusses the component technology to be assigned to cropping patterns, it will also identify subjects on which there is a lack of information that need to be studied at the site. This may be a need for further environmental description, such as better definition of the duration of irrigation, the time and frequency of rains, labor wage rates during harvest time, or the farmer's ability to identify insect pests. It involves the need for better component technology such as varietal screening, insect, weed or disease control, fertilization, tillage methods, or the date of establishment of different crops. During the first year it is often useful to do time of planting trials for the important crops at the site over their potential range of planting dates. These trials should be monitored for the occurence of insects and diseases. An early definition of response to major plant nutrients is also required. Component technology research is conditioned to the cropping pattern selected. It normally addresses only one crop of the pattern sequence and one or two variables, such as variety trials, tillage methods and subsequent levels of weed control, or method and rate of nitrogen application. Component technology trials are generally managed by the cropping systems researchers

rather than farmers.

The research team must be careful to study only those management components that have major impact on the economic performance of the cropping pattern. Generally the research focuses on the responses to inputs and leaves explanation of underlying mechanisms to the other physical and biological researchers.

Selection of factors and treatment levels

For the initial experiments, three general sources of information should be used to identify factors and treatment levels to be tested. Baseline surveys, a priori knowledge of crop requirements, and previous conventional field experiments conducted in the site area or in similar environments elsewhere. The latter may have been conducted in anticipation of a cropping pattern research program to follow or through the routine activities of organizations conducting multilocation trials. It is also advisable to identify the two management components that demand most cash and the two components that require most labor. Then estimate the effect on yield of changes in each of these components and evaluate the potential input savings or yield increases that could be derived from research on these factors.

Superimposed trials for component technology evaluation

Most component technology research should be closely associated with the cropping pattern tests and should be designed to test the present management assigned to the pattern. To insure close association with the cropping pattern trials much of this research should be conducted in the same fields in which the patterns are tested (hence the term superimposed).

At present it is recommended that the designs for the superimposed trials satisfy the following objectives.

1. Evaluate the return farmers derive from purchased material inputs used for weed control, fertilization and pest and disease control.

2. Evaluate the return the cropping pattern component technology obtains from these inputs.

3. Evaluate if possibilities exist for modification of the management components assigned to the cropping pattern for weed control, insect and disease control and fertilization that lead to increased yield.

4. Evaluate if these yield increases are sufficient to pay for the additional costs of the modified management components. To achieve these objectives, superimposed tirals must include the following component technology levels;

1. A simulation of farmers' management level

2. Farmers' management level without any purchased material inputs (if practical; if not attempt to reduce inputs on high cost factors).

3. The level of component technology assigned to the cropping pattern.

4. A level of component technology that is ~~empeded~~ expected to produce higher yields than the cropping pattern.

Various treatment designs can be used for superimposed trials, depending on the factors considered to be of importance. These trials evaluate the performance of the component technology across the land type and are therefore normally not replicated within a field. Each trials is established in 5 to 8 cropping pattern fields.

Research-managed trials

These trials are entirely managed by the cropping systems research team.

They evaluate in detail specific management components to be assigned to cropping patterns. They cover a wider range of management alternatives than the superimposed trials. Thus an increased number of variables and levels are included in the treatments. Research-managed trials seek to understand more precisely the type of responses to input levels and evaluate high risk treatments about which too little information is available to be included in cropping patterns managed by farmers. The results of research-managed trials are analyzed with an emphasis on treatment differences and require considerable precision. These results determine future changes in cropping pattern management levels and the management components to be studied in the superimposed trials.

The experimental designs for research-managed trials will not be discussed in detail. They follow the considerations of small plot experimental design on research stations. Because of limited field size, treatment numbers should normally be kept between 6 and 12. The number of replications should be three or more except where multilocation testing is involved in which case within field replications should be reduced to two as long as the total number of replications is four or more.

Research-managed trials can be conducted at research stations if the environment (climate, soils) at the station is the same as that of the land type studied at the site or if the purpose is strictly to compare treatment differences and no strong interaction with the environment is expected. In such cases, the site research team requiring the information should encourage researchers on the stations to conduct such experiments.

Whether conducted at a research station or at the site, these trials should use the same tillage methods and implement and the same component

technology (for fixed management) as that used for the corresponding crop in the cropping trials. For factors that are varied, the treatment levels must include those used in cropping trials and the high level treatment of the superimposed trials.

Limits to seeding dates that apply to that crop in the cropping pattern must be applied to the component technology trials. This is important as it will allow linking of the component technology research results to those of the cropping pattern trials. Where field x treatment interactions are considered important the number of fields should be at least four and within field replication can be reduced to a minimum.