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# THE PROCESS OF ON–FARM TRIAL DESIGN: THE HONDURAN EXPERIENCE OF 1978

FSSP

## Farming Systems Support Project

International Programs
Institute of Food and
Agricultural Sciences
University of Florida
Gainesville, Florida 32611

Office of Agriculture *and*
Office of Multisectoral Development
Bureau for Science and Technology
Agency for International Development
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# THE PROCESS OF ON-FARM TRIAL DESIGN: THE HONDURAN EXPERIENCE OF 1978

Daniel Galt
Associate Director, FSSP
International Programs
University of Florida
3028 McCarty Hall
Gainesville, FL 32611

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# PREFACE

For all the progress made in FSR/E in the past decade, the actual process of on-farm design remains one of the largest "black boxes" in the FSR/E sequence. This paper represents an attempt by the FSSP to stimulate submissions from FSR/E practitioners of current and relevant processes of on-farm trial design experiences. While the material contained in this Network Paper is dated, reflects a single person's biases, and is not meant as a guide to the best method of designing on-farm trials, it does represent a real field experience in trial design.

Since it is difficult for practitioners to find sufficient time for documentation, and because there has been a general reluctance on the part of current FSR/E practitioners to exchange their methods and processes of on-farm trial design, the FSSP feels that publication of something in this general area is better than publication of nothing at all. This is especially true since the design and analysis phases of FSR/E are those about which most first time practitioners exhibit the most concern. Futhermore, Dr. Hubert Zandstra of IDRC has been instrumental in encouraging the publication of this type of information, as well as lending his specific encouragment to Dr. Galt to draft and revise this paper.

Please read this Network Paper with the above thoughts in mind. We encourage as many of you as possible to document the process which your team uses during on-farm trial design. The FSSP welcomes submissions on the farm trial design process, and will do its best to publish as many as possible in the Network Paper Series.

Send your submissions to:

Steve Kearl, FSSP editor
IFAS/International Programs
3028 McCarty Hall
University of Florida
Gainesville, FL 32611

We need to continue to learn from one another. Let us hear from you.

Steve Kearl
January, 1986

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## INTRODUCTION

In Honduras, FSR began in early 1978 with an informal survey to help the farming systems unit focus on the potential research areas of the Comayagua Valley (Galt, et al., 1982). The Comayagua Valley is located in Region 2, the Central-West Region (FIGURE 1). The results of this survey were combined with a "pilot" survey in La Esperanza to design a formal, six-page farmer questionnaire. The formal questionnaire was administered in four different but relatively homogeneous zones in the Comayagua Region during the week of March 30-April 3, 1978. Surveys were carried out in the first and second homogeneous areas -- Flores and La Paz -- on Monday and Tuesday. The final formal surveys were completed in the third and fourth homogeneous areas -- El Rosario and San Jeronimo -- by Friday afternoon (FIGURE 2).

Formal analysis of the data collected was not performed by the survey teams. Instead, an agronomist/ecologist and an economist took the 111 surveys home on the weekend of April 4-5 and completed a partial analysis on those variables thought to be most valuable in assisting the farming systems team design farm trials. The analysis process consisted of summarizing all variables of most value for trial design per recommendation domain on spread sheets, deriving ranges and means for these variables using hand-held calculators, noting the frequencies of systems per domain, summarizing the planting details of the basic grains of the systems on the spread sheets, and summarizing this information in tabular form.

The process of team farm trial design began the following Monday and occupied the FSR unit for three days. Eight researchers representing the six disciplines of plant breeding, agronomy, entomology, agricultural economics, plant pathology and ecology participated. The whole process was quite dynamic and included a great deal of discussion among disciplines and researchers. Technical considerations were only a part of the relevant design criteria. Other design criteria included logistics, cultural practices, politics, estimated costs, and personal relationships.

## THE FARM TRIAL DESIGN PROCESS

The trial design meeting began by the team economist summarizing the findings of the "pre-analysis" exercise which had been carried out over the weekend. The parameters covered in the pre-analysis summary included a total accounting of the number of farming systems encountered in each recommendation domain, a summary of the three or four most common systems, the means and ranges of the yields of the crops in these most common systems, the number of total farmer-reported problems by crop within the systems, and a summary list of the three most commonly mentioned farmer problems from the previous total list. FIGURE 3 provides a summary of some of these parameters by homogeneous area (or recommendation domain) and component crop.

In addition to these system and component crop parameters, the details of the cropping patterns by crop and system were also summarized for each of the major systems within each recommendation domain. These summaries included (1) common name of farmer variety, (2) seed color (for maize and beans), (3) type of planting (broadcast, row or hole), (4) average number of seed planted per hole or row, or seeding rate, (5) distance between holes within rows (if applicable), (6) distance between rows (if applicable), and (7) depth of seed

FIGURE 1: ADMINISTRATIVE REGIONS OF HONDURAS

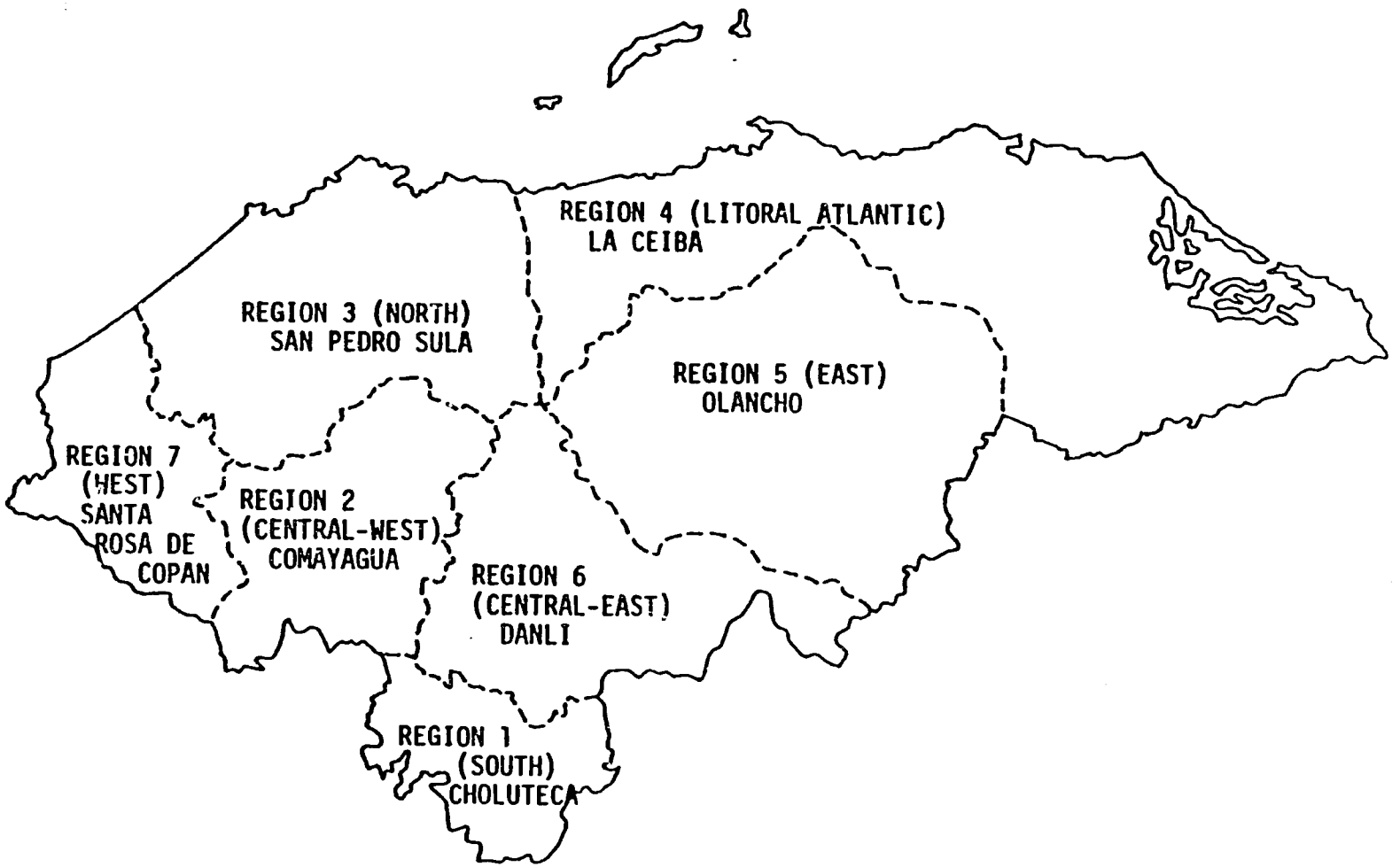

FIGURE 2 : RECOMMENDATION DOMAINS IN THE COMAYAGUA REGION OF HONDURAS, 1978-80

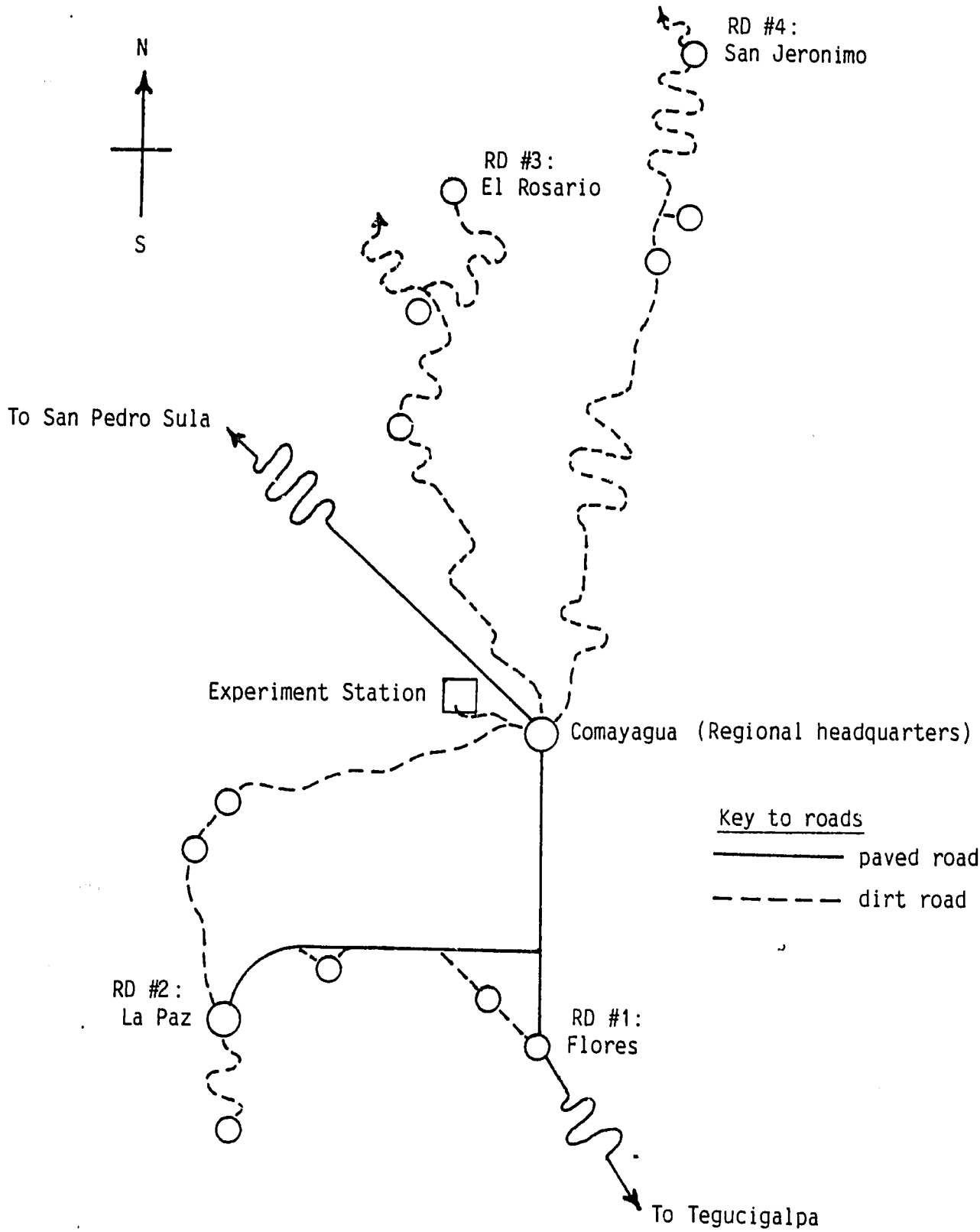

FIGURE 3. Characterization of FSR Zones, Comayagua Region of Honduras, 1978

| Zone | Is Irrigation a Possibility? | Percent Average Slope | Average Farm Size, Ha. | No. of Existing[a] Cropping Systems | In Order of Importance, the 3 Predominant Cropping Systems Identified Were: | In Order of Importance, the 3 Most Important Problems Listed by the Farmers Were: |
|---|---|---|---|---|---|---|
| Flores | Year-round | 0-2 | 5.0 | 25 | 1) Corn in spring followed by corn intercropped with beans in fall<br>2) Tomatoes in spring<br>3) Three tied for 3rd:<br>a) Corn monoculture<br>b) Rice monoculture<br>c) Corn in spring followed by tomatoes in fall | 1) Fall armyworm in corn<br>2) Bird damage in corn<br>3) Slugs (Babosa) in beans |
| La Paz | Supplemental | 0-2 | 10.6 | 19 | 1) Corn intercropped with sorghum in the spring<br>2) Corn monoculture<br>3) Cassava monoculture | 1) Fall armyworm in corn<br>2) Bird damage in sorghum<br>3) Bird damage in corn |
| El Rosario | No | 25-30 | 3.6 | 3 | 1) Corn in spring followed by beans in fall<br>2) Corn and sorghum intercropped in spring<br>3) Corn monoculture | 1) Slugs (Babosa) in beans<br>2) Two tied:<br>a) Fall armyworm in corn<br>b) Bird damage in sorghum |
| San Jeronimo | Yes, but currently there is almost none | 0-2 | 4.5 | 10 | 1) Rice monoculture<br>2) Corn monoculture<br>3) Corn intercropped with beans | 1) Fall armyworm in corn<br>2) Two tied:<br>a) Bird damage in corn<br>b) Carapacho in rice |

[a]As identified from 28, 28, 28, and 27 questionnaires for Flores, La Paz, El Rosario, and San Jeronimo, respectively.

planting.

Several additional parameters were added to the summary forms but rarely summarized for the group designing the on-farm trials. The parameters in this category included (1) farm size, (2) distance between fields and farm household, (3) age of farmer, (4) availability of supplemental irrigation, (5) type and average length of grain storage in-home, (6) seed source, (7) average price received for crop and (8) month(s) of peak labor need. These parameters were summarized by means only.

After examining the total number of systems by recommendation domain, the team retained domains two, three and four, but dropped domain one (Flores) from trial design consideration. The decision to eliminate domain one was based on three reasons: (1) there were too many systems (25 systems grown by one or more of the 28 farmers interviewed), (2) there was no predominant system based on basic grains, and (3) the typical planting time for the majority of crops -- vegetables -- was approximately two weeks away. The team unanimously agreed that there was not sufficient time to design trials, obtain seeds and necessary inputs, and contact collaborating farmers in Flores.

The design process began by listing the systems in the second recommendation domain (La Paz). In this domain, the 28 farmers questioned listed a total of 29 distinct systems (FIGURE 3). However, unlike the situation enclountered in Flores where no one system was predominant, in La Paz about 75% of the farmers followed one system: (maize + sorghum), while a second system, (maize - beans), was also common (FIGURE 3).

Source Of Diagnostic Data: Informal Versus Formal Surveys

The design process for trials in domain two was quite wide-ranging and discussion tended to be lively. This was due in part to differences between the results of the formal questionnaire as administered during the preceeding week and the rapid rural appraisal (formally named "sondeo" during March, 1978, by researchers in Guatemala) that the team had initially carried out in the region some two months earlier. We did not know it at the time, but much of the debate concerning reliability of data in a sondeo versus a formal survey would continue to be a major issue, off and on again, for at least the next seven years. However, acceptance of the rapid rural appraisal technique as one characterized as an efficient, accurate and valid scientific tool has been steadily increasing (Chambers, 1985; Conway, 1985a and 1985b; Galt, 1985; Rhoades, 1982). Indeed, some have suggested that rapid rural appraisal is more than a catchy tool, but represents an on-going paradigm shift in social science diagnostic methodology (Jamieson, 1985).

In some crucial aspects, the former informal survey was more reliable than the formal survey. This was particularly true for some details of the cropping systems which, the group felt, were better accessed by the informal questioning technique. The informal technique consisted of standing (or squatting) with farmers in their fields, and drawing their particular planting details on the ground with the help of a stick or pocketknife. In the more formal setting of the formal questionnaire process, questions were asked and answered in the more abstract environment of a farmer's home or store.

T observation that the informal information was often more accurate

than that collected formally lead the Honduran farming systems unit to agree that future surveys would be one of two types:

(1) "formal" sondeos utilizing a fixed, but flexible, set of questions to zero in on farmer's actual field practices, and

(2) follow-up formal surveys to take place after farm trials were in place, designed to elicit answers from farm households on specific details or processes within the given farm system which need further clarificaton. (Examples of such tailored, formal follow-up surveys administered by the unit in 1978 or 1979 included (a) greater detail on land preparation (including crop arrangements within systems), (b) soil fertility/soil degregation issues, (c) sesame cropping systems, and (d) bean cropping systems in two additional Regions of Honduras.

The contradictions between the informal survey activity and the formal questionnaire process were compounded by three additionals facts:

(1) the entire process of administering the formal questionnaire was done with only one relatively experienced practitioner,

(2) most of those questioning farmers had little to no experience in social science interview techniques, and

(3) little or no orientation preceeded the interviewing process.

These factors lead to the introduction of some unknown amounts of bias into either the asking of, or recording the responses to, certain questions. Some of this occurred even though the composition of each two-person interview team changed from day to day.

Finally, the farming systems team used a combination of the results from both the informal and the formal surveys during trial design. In the final analysis of the activity, common sense and group concensus often meant as much as "hard" means and ranges.

Technical Design Issues

Quite a bit of discussion centered around definition of the real systems in farmer's fields. Some examples follow:

(1) Did beans really follow the maize in field x, meaning that the system was (maize - beans), or were beans planted in only a portion of field x, meaning there were two systems: (maize - beans) and (maize), or were the beans actually planted in field y instead?

(2) Did farmers in domain two really plant (maize + sorghum) in three different spacial arrangements, and were they really incapable of telling us why these three distinct patterns existed, or were we not asking the right questions to find out?

(3) When the (maize + sorghum) was planted any other way but "casado" (both seed types together in the same hole), were the two grain types actually planted at the same time? Or was one planted later? If so, which

one was planted first? How much later was the second crop planted?

In addition to listing the most frequently-reported systems per domain, and attempting to agree upon what they actually were, frequencies of the most prevelant problems per system were listed in decending order. Thus, for example, in the (maize + sorghum) system in domain two, the problem most frequently mentioned by farmers was foliar insect damage. (Cogollero, or fall armyworm (Spodoptera frugiperda), was the most frequently-mentioned specific insect pest causing such damage.) In addition, in the (maize + sorghum) system in domain three, farmers again identified foliar insect damage as their most frequent problem. For this reason, it was decided to include an insect control trial in at least these two domains.

Political (Or Institutional) Design Issues

Another objective of the farming systems team during trial design was to encourage and build upon interactions with national commodity researchers. One way in which to do this is to specifically incorporate their most promising improved cultivars in on-farm trials. For this reason, another early design decision was to include variety trials in each domain.

A lot of team discussion followed from this decision. Questions included the following:

(1) What is the maximum number of improved varieties the farming systems team should request from the heads of the commodities we were mandated to work with (rice, maize, beans, and sorghum)?

(2) What is the minimum number of new varieties we should try to involve in any variety trial?

(3) Was sufficient seed available for all of the improved varieties we were going to ask for and, even if this amount of seed was initially available during first year trials, where would farmers obtain seed if they were to demand it the following year? (This question was especially troublesome for those varieties which were open-pollinated, such as maize and sorghum.)

(4) Should the testigo (or check plot) variety be

(a) that of each individual farmer,

(b) a "representative" variety bought from one of the collaborating farmers or from a store in the village near the center of the domain, or

(c) a composite formed by combining small samples of grain from each collaborating farmer?

(5) Should farmer practice, or recommended practice, be followed for plant and row spacings, or should a combination of the two be included in each trial (farmer spacing for farmer varieties; recommended spacing for improved varieties)? and, finally,

(6) In the (Maize + sorghum) system, should improved varieties of both maize and sorghum be combined in a single variety trial, or should the farmer's variety of maize be used with all improved varieties of sorghum and vice-versa with farmer's sorghum and improved maize varieities?

Specific Design Issues In Domain Two

In domain two, La Paz, the predominant systems actually were (1) (maize + sorghum) in the primera (first) season and (2) (maize - beans), covering both the primera and the postrera (second) seasons. From the results of the formal survey, the "beans" were not considered a part of the (maize - beans) system (FIGURE 3). Again, this is a problem which may arise from strict application and interpretation of formal surveys.

The major problems reported by farmers by basic grain crop are provided in FIGURE 5. Trials designed included (FIGURE 4):

(1) Maize varieties (5 improved cultivars + farmer's variety);

(2) [(Maize + sorghum) + soil insecticide] x 4 spacial arrangements;

(3) Maize + nitrogen fertilizer (two farms only for purposes of observation); and

(4) Legume varieties (5 improved cultivars + farmer's variety).

These researcher-planted, farmer-managed trials were planted on eight farms. Six of the host farms were privately owned, while two were farmer collectives (land reform groups, or asentamientos). The legume variety trial, which contained three improved varieties of common beans and one variety each of mungbean and cowpea, plus the farmer's variety, were planted in the maize variety trials in relay (to utilize the maize stalks as support) in the second (fall, or postrera) season.

On these eight farms, the two-man team assigned to La Paz was responsible for a total of 364 plots in 34 trials (counting the bean trials of the second season as eight distinct trials instead of as a part of the (maize - bean) system, which they really were). Plot size ranged from approximately 3.5m x 5m to 10m x 10m, depending on the trial and the method of planting employed by the individual farmer or farmer group. In general, these trials were superimposed researcher/farmer-planted, researcher-managed trials, although all non-treatment variables were managed by the farmer at planting, as were certain treatments. For example, the farmer planted all varieties in the maize and sorghum variety trials, so as to reduce the researcher introduced management bias at planting to a minimum.

Part of the reason there were so many plots was that, after a long discussion, the team decided that two replicates per site was the minimum statistically acceptable for the on-farm trials. Thus, each trial on each farm contained two replicates.

Maize variety trial

In designing maize trials, the team agreed to contact the head of the

FIGURE 4. Types of FSR Trials Conducted in the Comayagua Region, By Zone, 1978-80

| Zones: La Paz | El Rosario | San Jeronimo |
|---|---|---|
| **Year: 1978** | | |
| Corn varieties<br>((Corn + sorghum) + soil insecticide)<br>(Corn + fertilizer)<br>Legume varieties | Corn varieties<br>Sorghum varieties<br>(Corn + soil insecticide)<br>Legume varieties | Rice varieties<br>Rice demonstration lots<br>(Rice + weed control)<br>(Rice + fertilizer)<br>Soil insect control |
| **Year: 1979** | | |
| Corn varieties<br>(3 corn varieties + 2 bean varieties)<br>(Local corn+local sorghum) versus<br>(Local corn + improved sorghum)<br>((Corn+sorghum) + fertilizer)<br>(Corn varieties + fertilizr)<br>(Sorthum + spacing + fertilizer + management)<br>Bean varieties | (Corn + fetilizer)<br>Corn varieties: 3 maturities<br>Bean varieties<br>Soil conservation | (Herbicides + dosage + timing)<br>(Fertilizer + dosage + timing)<br>Rice variety trials |
| **Year: 1980** | | |
| Livestock trials, including:<br>-fodder from sugar cane<br>-livestock survey<br>-mixed farming systems<br>Corn varieties<br>Maturity: corn versus bean<br>Fertility | Corn varieties<br>Fertility<br>(Density + variety + fertilizer)<br>(Corn + sorghum) | Corn varieties<br>Rice varieties<br>Weed control<br>Date of planting |

FIGURE 5: MOST FREQUENTLY CITED FARMER PROBLEMS BY CROP, RECOMMENDATION DOMAIN 2, LA PAZ

| Crop | Number of Farms Growing the Crop (Total=28 Farms) | Number of Distinct Problems | Three Most Frequently Mentioned Problems and their Frequencies |
|---|---|---|---|
| Maize | 27 | 9 | Fall armyworm (includes "worm") =18<br>Drought = 9<br>Bird damage = 5 |
| Sorghum | 22 | 7 | Bird damage = 10<br>Drought = 9<br>*Gallina Ciega* (soil grub) = 2 |
| Bean | 12 | 7 | *Babosa* (soil slug) = 7<br>Drought = 3<br>"Diseases" = 2 |
| Cassava | 9 | 2 | Drought = 3<br>*Babosa* (soil slug) = 2 |

national maize program to obtain sufficient seed of the top five varieties recommended for the Region. These varieties became five of the six treatments included in a randomized complete block (RCB) design. The sixth treatment was the farmer's variety. The improved cultivars included materials from Guatemala as well as Honduras; white as well as yellow grain types. (The farmer survey questionnaire indicated that farm households raised and consumed both color types).

(Maize + sorghum) spatial arrangement trial

This major trial contained the three spacial planting systems followed by the farmers of La Paz. A fourth treatment, suggested by the ecologist, was the introduction of a spacial arrangement from an similar ecological area in Nicaragua for (Maize + Sorghum). The details of the four spacial arrangements are provided in FIGURE 6. The hypothesis for adding the fourth treatment was that double rows of maize and sorghum, in contrast to either single rows or mixtures of the two crops within rows, would lessen interspecies plant competition and lead to higher crop yields.

To check the economic importance of soil insects, a soil insect treatment was added to this trial. This was done to try to control Gallina Ciega (a white soil grub, or larvae), which was the third most common problem reported in sorghum in La Paz (FIGURE 5). The trial ended up as a RCB design, with soil insecticide (Aldrin at planting) versus no soil insecticide being the additional treatments.

Based upon extensive team discussion, control of foliar insects during the first year on farm was ruled out, even though this was the most frequently-mentioned farmer problem in La Paz (FIGURE 5). No treatment to control Cogollero, or fall armyworm, was included because two of the researchers had experience working with foliar maize insects in Mexico, and unanimously recommended that more research be conducted on-station before exposing farmers to farm trials. Discussion on this issue revolved around the following:

(1) the most efficacious insecticides for control of foliar maize insects were judged to be either too expensive to recommend for farmer's use without first conducting timing trials on-station to establish the best time of application, or were locally unavailable, and

(2) the less expensive insecticides for use on maize were priced so competatively because they were being dumped on Honduras by their primary producers since having been banned for use in the U.S. by the Environmental Protection Agency (EPA).

The farming systems unit then decided that no farmers should be encouraged to purchase these lower priced but less efficacious and environmentally suspect insecticides in the first year of on-farm research. When the team did include one of these insecticides (Aldrin) in La Paz for control of soil insects, the team itself applied the insecticide to avoid any potential health-related problems with farmer households. This method of application did not resolve the dilemma of what would be done at the recommendation phase if such a treatment proved to be an economic improvement over farmer practice, although the team agreed to test a substitute insecticide at some future point

FIGURE 6: SPACIAL ARRANGEMENT DETAILS OF THE (MAIZE + SORGHUM) SYSTEM

Arrangement 1 (Honduras)

| | | | |
|---|---|---|---|
| x | o | x | o |
| x | o | x | o |
| x | o | x | o |
| x | o | x | o |

Arrangement 2 (Honduras)

| | | | |
|---|---|---|---|
| x | o | x | o |
| o | x | o | x |
| x | o | x | o |
| o | x | o | x |

Arrangement 3 (Honduras)

| | | | |
|---|---|---|---|
| xo | xo | xo | xo |
| xo | xo | xo | xo |
| xo | xo | xo | xo |
| xo | xo | xo | xo |

Arrangement 4 (Nicaragua)

| | | | |
|---|---|---|---|
| x | x | o | o |
| x | x | o | o |
| x | x | o | o |
| x | x | o | o |

Key to crops:

x = Maize

o = Sorghum

in the farm trial phases.

A second team discussion lead to another decision which affected the method of providing recommended inputs to collaborating farmers. With the exception of the two collaborating cooperative farm groups in the domain, the small producers had no chance of obtaining credit through official channels. Since the team was working with the poorest farmers in each domain, it was decided that outlays for on-farm inputs in any given trial would be limited to a maximum of L 50.00 (U.S. $25.00) per farm household in subsequent years. During the first season of exploratory trials, any needed inputs were provided by the farming systems unit. However, never were more than two inputs provided (seed and insecticide or fertilizer) per trial.

Sorghum trial

In this domain (FIGURE 5), drought is the problem ranked second in importance by farmers growing all three of the major grain crops listed. The farming systems team decided that, in the short run, there was no readily apparent policy solution (such as more, or better distributed, irrigation water) to this problem. However, from the rapid rural appraisal survey, the team knew that farmers' use of sorghum in the (maize + sorghum) system was a risk-aversion tactic employed to reduce the potentially adverse effects of drought. The team agreed to try to obtain and use some of the sorghum cultivars recommended by the head of the national sorghum breeding program for drought conditions. This was another example of positive interaction between the farming systems unit and commodity researchers, and marked the first time in Honduras that these sorghum varieties had been subjected to testing under natural rainfall on-farm.

Finally, the most frequently mentioned problem farmers indicated for their sorghum was grain damage by birds (FIGURE 5). To address this issue, the head of the sorghum program was contacted again for advice, and agreed to provide sufficient seeds of two distinct sorghum head types:

(1) the open, long-panicled type, and

(2) the closed, short-panicled type.

Use of these two types in farm trials allowed on-farm examination of which head type suffered the least loss from natural bird damage in the region. This is a positive example of how reserch priorities of the team may be identical to those of a major commodity program. The head of the sorghum program welcomed the chance to expose different sorghum head types to significant bird damage under farmers' conditions. The head of the sorghum program also assisted the team in developing guidelines for quantifying bird damage to heads of the sorghum plants during the growing season and at harvest. The sorghum variety trials were all of the RCB design.

Bean trials

Design of bean trials to follow maize in relay in the second (fall) season included both red and black beans. Red and black beans were included since both types were grown and consumed in the domain. The major differences between the two color types are yield and preference. Preferred red bean

yields are about one-half those of black beans, whereas prices of black beans are approximately one-half those of reds. In addition to these two traditional bean types, the decision was made to incorporate two non-traditional types in the trials: (1) a mungbean variety and (2) a cowpea variety. Thus, the bean variety trial contained a mixture of traditional and non-traditional beans, including each farmer's variety. These trials were all RCB in design and were planted in relay after the maize harvest.

Use of the experiment station for support/backup trials

During the discussion of La Paz trials, the question of station trials arose: how could such trials complement and reflect on-farm investigation? At this time, a healthy debate sprang up around the general issue of input availability. The specific question was the recommended use of the herbicide glyphosate (Roundup) to control nutsedge (*Cyperus esculentus* L.), the most noxious weed on-station. The two sides of the argument were:

(1) glyphosate should be used because it was the most efficacious herbicide for the job, and

(2) glyphosate should not be used because it was not available in Honduras.

Further discussion centered on the fact that trials using this herbicide would have long-run implications, but that no useful short-run conclusions could be drawn for farmer collaborating in on-farm trials. The decision was finally made that no unavailable inputs would be used in the farming systems trials, even for those conducted on-station.

Station trials were designed later during the growing season to address the problem of control of babosa (*Vaginulus plebejus* Fisher, or *Limax maximus* L.), a soil slug now acknowledged by CIAT bean entomologists as the most serious economic pest of common beans in Central America. Babosas were identified by farmers as the most severe problem in their beans (FIGURE 5). As soil slugs were just beginning to emerge as serious problems in common beans in various parts of Central America at this time, not enough was known about control options to recommend anything on-farm.

This concluded the design process for trials in the domain of La Paz. Combined analysis of experiment station trials with farm trials using modified stability analysis (Hildebrand, 1984; Hildebrand and Poey, 1985) was not done, although each farm trial type was replicated exactly on-station.

Specific Design Issues In Domain Three

In domain three, El Rosario, only three distinct systems were mentioned by the 28 farmers interviewed during the formal questionnaire survey process (FIGURE 3). This is in marked contrast to the 10 systems in domain 4 and the 29 systems in domain 2 (FIGURE 3).

The three systems identified in El Rosario were:

(1) (maize - beans) (as in La Paz),

(2) (maize + sorghum) (as in La Paz), and

(3) Maize sole cropped in the first (spring) season.

(Maize - beans) was identified as a system used by 100% of the farms surveyed, while (maize + sorghum) appeared on 61% of the farms surveyed and maize as a sole crop was on only one surveyed farm.

Design of trials for this domain naturally revolved around maize, sorghum and beans. The most common problems in maize, according to the farmers surveyed, were (1) fall armyworm damage, (2) bird damage and (3) (tied with bird damage in frequency) medidor (another foliar maize insect pest) (FIGURE 7). The most common problem identified by farmers for beans was babosa, the soil slug also identified by farmers in La Paz as the major problem in their beans. Finally, the most frequently-mentioned problem in sorghum was bird damage (FIGURE 7).

During discussion of possible farm trials for the domain, it was generally agreed that this domain was closest to the "edge" of subsistence, and that risk aversion was a high priority of the typical farm household. Water was scarcest in this domain, with rainfall being most problematic of the three domains, and supplementary irrigation an impossibility. The average family farm slope ranged from gently rolling to above 55%. For these reasons, simple, low-cost farm trials were agreed upon as a necessity for the farmers of El Rosario.

Again, the decision to access promising varieties from national commodity programs led to two variety trials out of a total of three trial types. The trials finally designed for the domain were:

(1) improved maize varieties (four improved varieties + the farmer's variety) in a RCB arrangement. This trial also hosted the improved beans trial during the second (fall) season (refer back to the bean trials of La Paz for details, as they were identical),

(2) improved sorghum varieties (four improved varieties + the farmer's variety) also in a RCB arrangement, and

(3) A split plot trial imposed on the (maize + sorghum) system. This trial included an application of the insecticide Aldrin to the soil (in each hole dug by a planting stick) at planting time versus no insecticide, and included both the farmer's variety of sorghum and an improved variety of sorghum grown together with the farmer's variety of maize.

The two-man team assigned to this domain ended up supervising 21 individual trials on eight farms, consisting of 196 separate treatments or plots. Again, as in La Paz, each trial was replicated twice. Also, these trials generally represented superimposed, researcher/farmer-planted, researcher-managed trials (see previous discussion on La Paz for planting routines followed), with farm family labor being used as much as possible to reduce research-introduced management confounding to a minimum.

(Maize + insecticide) trial

FIGURE 7: MOST FREQUENTLY CITED FARMER PROBLEMS BY CROP, RECOMMENDATION DOMAIN 3, EL ROSARIO

| Crop | Number of Farms Growing the Crop (Total=28 Farms) | Number of Distinct Problems | Three Most Frequently Mentioned Problems and their Frequencies |
|---|---|---|---|
| Maize | 28 | 20 | Fall armyworm = 9<br>Medidor (worm) = 6<br>Bird damage = 6 |
| Bean | 28 | 14 | Babosa (soil slug) = 10<br>"Escarabajo" (insect) = 7<br>Medidor (worm) = 6 |
| Sorghum | 17 | 7 | Bird damamge = 9<br>"Ice" (brown plant disease) = 2<br>"Bulbo" (unknown cause) = 2 |

The third trial type represented a classic example of a farm trial designed in the interdisciplinary mode. Since the farmer survey indicated that insects were a problem in maize, the main plots in the split plot design contained either an application of Aldrin to the soil at planting, or no insecticide. Aldrin was chosen only for its low cost and general wide availability to farmers in the domain, not because the team was comfortable recommending a pesticide banned by EPA in the U.S. Use of Aldrin as the soil insecticide represented the classic trade-off between (availability + low price) versus (efficacy + safety).

Sorghum variety trial

One of the improved varieties of sorghum recommended for this trial was thought to have some degree of drought tolerance by the head of the sorghum program. It was hoped that the improved sorghum would out-yield the farmer's variety in a direct comparison, especially under low or sporadic rainfall. This drought tolerance was considered to be of high importance in a zone where drought was so endemic that it was not mentioned by the farmers as a problem during the formal survey process. Again, this points out a major difference between a formal and informal diagnostic approach. During the rapid rural appraisal earlier in the year, farmers explained that planting was absolutely determined by the first spring rains, and that this timing was the most critical aspect of management of their cropping systems. However, during the formal survey, the problem of absolute dependency upon the start of rainfall — and its corollary, drought -- were not mentioned as problems in the region. Most probably this is because the start of the rains and the possibility of drought are integral parts of the system in farmer's minds, and are not viewed as "problems" to be mentioned during a survey.

Use of tailored, follow-up questionnaires

After the farm trials were planted in this domain, a second formal questionnaire was administered to farmers. This questionnaire focused on soil conservation issues with which the farming systems unit became increasingly concerned during the cropping season. The analysis of this questionnaire resulted in further design and implementation of several ad hoc soil conservation trials. Such trials consisted of comparing two types of live contour plantings to control erosion and start the slow but necessary process of building up contours in some of the more steeply-sloping farmer's fields. The two types of live plant materials used to construct these contours were perennial sorghum and pineapples.

Pineapples were added to these trials only after a lengthy discussion, characterized by the presentation of several eloquent arguments and counter arguments, and only after the team's agronomist promised to "obtain the pineapples by himself, at his own expense, and without use of program vehicles." It can be seen that even in a relatively smoothly-running interdisciplinary team, certain decisions must be made unilaterally.

Specific Design Issues In Domain Four

In domain four, San Jeronimo, a total of 10 cropping systems were identified (FIGURE 8). In decending order of importance, the major systems identified were:

FIGURE 8: MOST FREQUENTLY CITED FARMER PROBLEMS BY CROP, RECOMMENDATION DOMAIN 4, SAN JERONIMO

| Crop | Number of Farms Growing the Crop (Total=27 Farms) | Number of Distinct Problems | Three Most Frequently Mentioned Problems and their Frequencies |
|---|---|---|---|
| Rice | 20 | 11 | Drought = 9<br>Carapacho (stem insect) = 5<br>two tied:<br>Bird damage = 2<br>"Diseases" = 2 |
| Maize | 24 | 11 | Fall armyworm = 7<br>Bird damage = 5<br>two tied:<br>Medidor (worm) = 4<br>Gallina Ciega (soil grub) = 4 |
| Bean | 9 | 7 | all tied:<br>Thrips = 1<br>Babosa (soil slug) = 1<br>"Ice" (brown plant disease) = 1<br>Medidor (worm) = 1<br>Drought = 1<br>Gusano (worm) = 1<br>Diabrotica (Diabrotica spp) = 1 |

(1) rice planted in monoculture in the spring,

(2) maize planted in monoculture in the spring,

(3) coffee (grown in the mountain holdings of the farmers who lived in the river valley), and

(4) (maize - beans) (FIGURE 3 lists 1, 2 and 4).

Note that coffee is not listed in FIGURE 3. This was because the farming systems unit was bound by the Honduran government's five-year plan to focus on research in basic grains. Research on coffee came under the mandate of an autonomous Honduran research entity, ICAFE. For this reason, team trial design discussions centered on the problems of the predominant basic grain grown in the domain: rice.

In fact, only after a great deal of discussion was it decided to design only trials which involves rice during the first year's research. Neither maize nor beans were researched during the first season. Maize was ignored because (1) conducting systematic maize trials might have meant sampling a second group of farmers to act as collaborators, as rice farmers were not necessarily maize farmers and vice-versa, and (2) the team assigned to this domain began with only one individual whose specialty happened to be rainfed rice research. The group decided it would be too much work to assign a heavier farm trial load to only one researcher. In fact, this one researcher was soon joined by a Honduran counterpart but, during trial design, it was not at all sure that a two-person team would be available for research in this domain. Beans were ignored for both of the above reasons, as well as for the fact that maize in monoculture appeared to be about three times as common as the (maize - bean) system.

Farmers surveyed identified the following as being the most frequent problems in rice: (1) drought, (2) carapacho damage (an insect pest), and (3) (two tied) bird damage and diseases (FIGURE 8)). Almost all rice in San Jeronimo was already planted with fertilizer (either 12-24-12 or 15-15-15), but no other inputs were used routinely. Thus, fertilizer became a part of the check plot in each trial.

Rice variety trials

The team discussed the problem of drought in the domain. Some farmers and cooperative groups of farmers used pumps to supplement rainfall, while others did not. It was finally decided that the best way to address the problem of drought was through the rice variety trial. Including the most promising varieties from the national rice breeding program was one of the goals of the first season's on-farm trials. Thus, the decision was made to include extra rice varieties in the trial which had showed signs of being drought tolerant in station research trials. So, instead of five improved and one farmer's variety, these trials consisted of nine improved varieties and one farmer's variety, for a total of ten treatments. The agronomist assigned to this domain was given the task of making the final variety selections in consultation with the head of the national rice research program.

Actually, during the trial design process, the final number of treatments

in the rice variety trial was unknown. While the farming systems unit realized that more than five varieties would be involved, an upper limit of no more than 12-15 varieties was agreed upon. The final number of nine improved varieties was agreed upon later the team agronomist had consulted the national head of the rice breeding program. In addition, availability of seed forced the team to eliminate four of the improved rice varieties from trials on several farmer's fields when the trials were actually planted in the following weeks. However, the same five improved varieties were always used in these smaller trials. The rice variety trials were RDB designs with two replicates.

Rice insecticide trials

To address the problem of carapacho damage on the rice crop, a separate insecticide trial was designed. This trial consisted of two treatments: the farmer's variety, which was usually (CICA 6 + fertilizer), with and without insecticide -- carbofuran (Furadan) 5% granuals -- applied to the soil in rows at time of planting. This is an example of adopting an available shelf technology to initial farm trials. Once again, the team entomologist played a key in the design and planning of this trial. Limitations of available land also meant that there was no room for the insecticide trial with two of the collaborating farmers with the smallest fields.

Rice weed management trials

Finally, the formal farmer survey in the domain lead the farming systems unit to believe that the most labor-intensive activity during the rice season was weeding. Such activity not only required much hand labor, it also required more oxen teams for cultivation than were in the region. Thus, more efficient weed control appeared to be a high priority of the domain. This specific problem was not explicitly mentioned by the farmers questioned during the formal survey process.

To address this issue, a RCB design weed control trial with five treatments was developed. The treatments selected were: (1) farmer check (farmer weed control practice), (2) application of Stam F-34 to replace a hand weeding, (3) application of 2,4-D to replace a hand weeding, (4) a combination application of (Stam F-34 + 2,4-D) to replace a hand weeding, and (5) no weed control.

The last treatment, to enable the team to assess the economic impact of general weediness on yield, was added only after another protracted discussion. On the one hand, it was correctly pointed out that none of the farmers practiced zero weed control and that this treatment was less than meaningless to them. Indeed, it represented a practice the farmers would think of as extremely stupid. On the other hand, while those arguing for the inclusion of this treatment agreed with this general argument, they pointed out that the unit could agree to compensate the farmers for the rice yield lost by including this treatment. Those assigned to work in San Jeronimo could explain the rational of the treatment to the collaborating farmers. This rationale was that this treatment represented a low-cost method of obtaining a reliable field estimate of the average economic impact of weeds in the domain upon yield.

The team placed greatest emphasis on the weed control trial, the next

most emphasis on the variety trial, and the least emphasis on the insecticide trial during the first season in this domain, even though drought and *carapacho* damage were cited by farmers as their most severe problems in rice. The two-person team covering the San Jeronimo area ended up with 14 trials on six farms consisting of 172 total treatments or plots. Again, each trial was replicated twice. These trials were superimposed, researcher/farmer planted, researcher-managed trials. Again, farmer management at planting was maximized to minimize researcher-introduced management confounding.

## RECOMMENDATIONS

Several interdisciplinary issues were important in the design of trials in each recommendation domain. These issues generally arose each time a trial was proposed and discussed. These topics included the following:

(1) the number of farms which would constitute a minimum representative sample of the farm households in a given domain for each system being researched,

(2) replication of trials at each farm site,

(3) size of any treatment plot within a given trial,

(4) division of the farming systems unit into two-person teams (one per recommendation domain), and

(5) overall logistics, division of labor, and vehicle assignment and availability.

Each issue will be discussed in turn briefly below.

### Farm number: Statistical representation versus work overload

There were two basic issues to be addressed regarding farm numbers. These were

(1) the desire to include as many farms as possible to insure the representativeness of the sample from the given domain, and

(2) the desire to include less farms, but to make sure that a tighter sample of collaborators was drawn to represent more closely a chosen sub-set of clientele.

The dilemma of adequate sample size always comes up in farm trial design situations. Usually the underlying variability of the domain is unknown, making it literally impossible to know with certainty how many farm households should be selected to collaborate with trials in the domain. Estimates in this team setting ranged from five to 25 farms. To compromise, eight to ten host farms were chosen for the major trials in each domain. Lately, Hildebrand has shown how on-farm research teams can explicitly include on-station trials in evaluation of technology (Hildebrand, 1984; Hildebrand and Poey, 1985). However, this issue of proper station/farm research interface was never resolved by the farming systems research unit in Honduras.

Trial replication

The number of replications per trial and the size of each plot per trial are related issues which received considerable attention. (Plot size is considered in the next sub-section.) The team decided to compromise between no replicates (or the use of farm site as the only source of replication) and the four replicates traditionally used by agronomists in their work on experiment stations.

Initially, the FSR unit hoped that three replicates could be used for certain trials, but after all trials were designed and two-person teams had been assigned to each domain, the group soon realized that the size of the overall work load precluded including a third replicate for any of the trials.

Plot size

Plot size as an issue was settled in nearly the same manner as number of replicates. In general, the team began by trying to decide what the smallest acceptable plot size would be, by crop (or by system when more than one crop was to be grown in the plot per year) and by trial type. Once such a minimum plot size was agreed upon, the group considered larger plots. However, the size of the workload prevented the team from expanding plot sizes in any trial type.

Generally speaking, the plot sizes were four or five rows in width by 5m in length for maize, sorghum and beans, and 5m x 5m for rice. The only time larger plots were used was in the spacial arrangement trials in domain two (La Paz). In this case, each plot averaged nearly 10m x 10m. However, since the team had little experience in spacial arrangement trials, there was no "guarantee" that these 10m x 10m plots were of adequate size.

Division of the FSR unit into sub-teams by domain

A fair amount of time was spent discussing how the farming systems unit would divide personnel responsibilities between the three domains. Since three of the four expatriates in the unit were not native speakers of Spanish, each was initially assigned to a different domain. Then the native Spanish speakers were assigned to regions to complement the expatriates.

However, assignment of personnel to domains was not a random process. The individual with expertise in upland rice research was assigned to domain four (San Jeronimo) where rice trials formed the backbone of research on farmer's fields. The rest of team personnel chose the recommendation domain of their own preference (subject to the language ability constraint noted above). Unfortunately, during the early weeks of farm trial implementation, such an assignment of personnel meant that the expatriate with the least amount of working Spanish ended up alone in domain four. This situation was soon remedied by adding a Honduran counterpart to that domain, but other teams should be aware of language constraints when assigning research (or extension) personnel to various regions of any given country.

Logistics and the division of labor

Finally, major discussions of logistics, potential labor bottlenecks and

vehicular requirements took place toward the end of the three-day design session. It was pointed out that at trial design time, the unit had only one assigned vehicle, but needed a minimum of three to work effectively in the domains (FIGURE 2). These domains were separated by a distance of between 45 minutes and one hour and 15 minutes. The unit agreed to seek assistance from the donor sponsoring one of the expatriates in the unit for continued vehicular support until the two work vehicles on order arrived. Permission was obtained, and this expatriate contributed his personal and work vehicle to the early efforts of the team.

In addition, the CATIE outreach ecologist stationed in Honduras loaned his vehicle to the unit upon his departure to CATIE headquarters in Turrialba, Costa Rica. These two ex-oficio vehicles, plus the one Toyota Land Cruiser seconded to the unit from the Honduran Coffee Rust Campaign, enabled the unit to carry out its necessary field work during the first year's trials.

The issue of labor bottlenecks within the interdisciplinary unit was also discussed. The issue involved the anticipated planting and harvesting bottlenecks which always arise during any cropping season. It was agreed by all in the trial planning meeting that the following policy would be adopted: whenever a two-person team did not have top priority field work to do, and the team in another domain needed extra hands for planting or harvesting, the team with slack time would assist the other team in planting, monitoring, or harvesting activities. Thus, field work took priority over both analysis and office work.

The same general policy applied to vehicle assignments. Each two-person team was assigned a work vehicle. Sharing of vehicles between domains occurred when and if the need arose.

In actual practice, these policies worked out pretty well. The only exception was that the first domain planted received the most assistance from other two-person teams, while the last domain planted received the least assistance from others. However, there is no substitute for guaranteed mobility to the field during critical stages of cropping and/or livestock trials. Two ways to assure such mobility are:

(1) assigning a work vehicle to each domain, or

(2) physically locating sub-teams in the domains (or villages) where their farm trials are located.

## CONCLUSIONS

Anyone can design crop trials. Agronomists, breeders, plant protection specialists, biometricians and statisticians do so all the time. However, many factors other than technical ones must be considered during any process of farm trial design.

Farm trials in FSR/E are designed by groups or teams with certain interests and goals in common, but the team will almost never be in total agreement. Compromise is the key to a successful team trial design effort.

The disciplinary composition and age distribution of team members are also important factors. The political mandate of the research organization, and of the FSR/E research team, must be considered. The institutional setting and the interpersonal relationships between traditional researchers and the FSR/E team researchers must also be considered. Existing research results, directions, goals and objectives, and breeding pipelines, must all be examined for relevant ideas, materials and thrusts. Researchers in charge of each commodity and disciplinary program should be included in the decision-making process whenever their disciplines or commodities will play major roles in the farm trials designed by the FSR/E team.

In addition, the total number of important, researchable problems or constraints will always exceed (1) the amount of available technology which can be brought forward to address the needs, and (2) the capacity of the FSR/E team to implement, monitor, harvest, analyze and interpret results within these problem areas. Therefore, the trial design process must always include a great deal of prioritization. Top farmer-identified problems, given the greatest amount of emphasis in design of on-farm trials, may need to be shifted in light of existing knowledge concerning solutions to them. Other lesser priorities may be elevated to farm research status level, while reality dictates that some of the farmers' more pressing needs must be researched first at the experiment station level.

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