~~THE~~ CIAT BEAN PROGRAM'S APPROACH TO SYSTEMS-BASED RESEARCH

Jonathan Woolley and Douglas Pachico

Paper prepared
for the IARC Workshop on Farming
Systems Research. ICRISAT,
February 17-21, 1986.

CIAT
Cali, Colombia
October 1985

1. INTRODUCTION

This paper analyzes the approach to systems-based research of one of CIAT's commodity programs, the Bean Program. It is motivated by our agreement with other IARCs on the need for a clearer understanding of the commonalities between IARC approaches and the reasons for differences when these exist.

The meeting of representatives of the IARCs active in systems-based research in eastern and southern Africa (at ILRAD, Nairobi in October 1984) revealed much more agreement than might have been expected on the type of approaches suitable for Africa. CIAT hopes that this can also be encountered when we study approaches in different continents.

In CIAT, the term "on-farm research" (OFR) is applied to a range of systems-based research activities which a) start from an understanding and analysis of farmers' circumstances and b) are carried out in farmers' fields under their conditions. We prefer the term "OFR" to "farming systems research" (FSR) since we work on sub-systems within the whole farming system.

In CIAT there is no Farming Systems Program per se. Instead, three commodity programs work in OFR; cassava, tropical pastures and beans. Approaches differ because of the very different nature of each commodity. This diversity has been a strength in that it alerts us to the broad range of activities which may validly be described as OFR, without necessitating the formulation of a uniform centre-wide approach to OFR.

The Cassava Program has an integrated development strategy for cassava improvement. This is based on the execution of pilot projects which integrate production, processing and marketing activities. It includes the type of on-farm production research described later for the Bean Program. It also includes, however, the study of traditional and new methods of processing the product as well as the identification and promotion of alternative markets for cassava and its derivatives. (CIAT, 1985a).

OFR activities of the Tropical Pastures Program differ from the crop OFR focus, mainly due to complex interactions of the animal component and perennial pastures which require long term evaluations and are also costly. These factors have led to an approach with four characteristics. Longer term diagnostic studies of prevailing production systems are emphasized; bioeconomic simulation is used extensively to reduce the number of options to be tested in the field; a few selected options are tested on-farm over lengthy periods, generally with only one or a few treatments per farm; and the performance of the technology as used by early adopters is monitored so as to feed information back to the research process. Thus the efficiency of experimentation is maximized by its use in conjunction with other techniques (Vera and Sere, 1985).

OFR in the CIAT Bean Program is the subject of the remainder of this paper. The work described is conducted by a small group of scientists who are integrated with the rest of the Bean Program. The senior staff scientists most involved in OFR work are a Cropping Systems Agronomist and an Economist based in Colombia together with an Economic Anthropologist and an Agronomist in the Great Lakes Region of Africa (Rwanda, Burundi and the Kivu region of Zaire).

Five themes run through the work. Firstly, we try to assimilate and apply experiences and procedures of other institutes both international and national, in order to benefit from the latest developments in other programs. Thus we avoid "reinventing the wheel". We believe this makes CIAT's experience useful in the present workshop. Particularly strong influences on us have been CIMMYT and ICTA Guatemala. At an early stage in the expansion of OFR activities in the Bean Program, five experts from outside CIAT, with experience from Latin America, Africa and Asia, were invited to advise the Program on the future direction of its OFR.

Secondly, we concentrate work in the part of the crop sub-system which includes beans and associated crops. This is a direct result of our commodity mandate. Geographical work areas are chosen so that the bean sub-system is a key enterprise which offers possibilities for improving the farmers' well-being. Although work is focused on a sub-system, interactions with other sub-systems of the farm are taken into account. Successful technologies within the bean enterprise are compared with other farm enterprises before recommendation and promotion. Beans are almost always grown in association with other crops, so the Program has emphasized methodologies suitable for sub-systems with more than one crop in association. Since grain type preferences are often a major limiting factor in the adoption of new bean varieties, marketing activities and consumer preferences are related systems outside the farm which have typically received more attention than is usual for some crops handled by other IARCs.

Thirdly, although we work in OFR primarily through national agricultural services (NAS), we see value in carrying out OFR activities in a few representative areas as a direct CIAT activity in order to study the consequences of different OFR procedures. It also permits us rapidly to generate information on farmer circunstances and technology performance in these areas so as to orient on-station research. Even where OFR is a direct CIAT activity, NAS are actively involved in planning and execution. The responsibility for planning and conducting the work passes completely to NAS after a few years.

Fourthly, we regard the sites where we collaborate in research more as testing places for strategies than for specific technologies. "Strategy" refers to the choice of which specific on-station and on-farm research procedures to use according to NAS needs and resources, and the amount of time spent on each procedure. The emphasis on strategy rather than technology stems from the diversity of growing conditions and consumer requirements for beans. It also results from the need to offer our experience in a few regions as a guide to those in other countries and regions.

Finally, we are particularly interested in understanding how to integrate technology adaptation on-farm with technology development, whether on-station or on-farm. In our experience, some activities traditionally regarded as "basic" technology development may be better done on-farm than on-station. This is discussed further in section 4.

2. OBJECTIVES

In the interests of searching for commonality with other IARCs, the objectives of the CIAT Bean Program's OFR can be classified according to those in the summary of the Inter-Centre Consultation in Nairobi (IARC, 1985).

1. Building up the capability of national institution personnel to do OFR, for improved relevance in technology development and adaptation.

2. The diagnosis of constraints to help set priorities in CIAT and NAS research efforts.

3. Development of methodology and involvement of CIAT personnel on-farm.

4. Development of new technologies under farm conditions. Technology development is distinct from diagnosis and from short-term adaptation of technology to a specific location. It is discussed further in section 3.3.

5. To test, monitor and understand adoption of technologies.

For the CIAT Bean Program, objectives 1 and 2 receive top priority and objective 3 second priority, followed by objectives 4 and 5.

All the objectives have the NAS as the final client. However, in objectives 2, 3, 5 and part of 4, CIAT is the immediate user.

Objectives may be achieved directly or indirectly. For example, work for objective 1 is also effective indirectly for objetives 2, 3 and, eventually, 5.

3. THE STATE OF THE ART

In this section the OFR procedures used when the goal is short-term technology adaptation to specific areas will be discussed first. An approach which is intended for use where OFR teams do not exist will then be described; this is termed on-farm variety testing (OFVT) and is a simplified OFR strategy. Thirdly, technology development on-farm will be considered. Finally, the role of OFR will be noted in generating for CIAT and NAS station scientists information about farmer problems, practices, resources and objectives as well as feedback on the performance of new technology in farmers' situations over a diverse range of conditions. In all cases, the procedures described are intended for use by NAS.

3.1 OFR for technology adaptation in the short-term

A model for OFR (Figure 1) has been found useful for Bean Program OFR activities with NAS. In collaborative work with national programs in Latin America, considerable emphasis has been placed on modifications of the model to fit the circumstances of individual institutions. In CIAT training activities, collaborators learn and discuss the purposes of each stage in the OFR model. They consider the tradeoffs, if a stage is eliminated or modified, between information lost and speed gained or resources saved. In the Program's experience, this has made possible the gradual introduction or improvement of OFR techniques in countries where no clear institutional commitment to OFR could be obtained at the start. There is not enough evidence yet on this approach to be certain that it is preferable to teaching a more rigid "recipe". CIAT does feel, however, that a flexible approach is more likely to be acceptable, because of the great variation between national institutions in their staff numbers, experience and resources. Farming circumstances also differ from country to country.

The stages in the model are grouped into a) diagnosis, b) choice of trial content, c) experimentation, interpretation and recommendation and d) interface with extension.

a. Diagnosis

When possible, the assignment of priorities between potential study areas prior to diagnosis is based on the mapping of microregions according to climate, soils and production data. Diagnosis covers a wide range of research endeavours. Simple, rapid and inexpensive techniques are used. The aim is to proceed as rapidly as possible to experimentation while ensuring the quality of the information obtained.

The stages which should be conducted before experimentation commences are the compilation of secondary information, reconnaissance and a survey (Figure 1). The reconnaissance and survey include interviews with farmers and field observations of crops. They are focussed on the sub-system which includes beans (Table 1). The reconnaissance is used as a pre-screening for the survey which follows it immediately. Extensive use is made of the farmer's existing knowledge. When there is more than one cropping season, these are described and diagnosed separately.

Diagnosis does not finish when experimentation starts. The results of experimentation, especially variety trials and exploratory trials, lead to confirmation or modification of the diagnosis of principal constraints (Figure 1). Within survey activities, special studies are carried out according to the needs of the particular situation and the technologies being tested (e.g. farmers' attitude to mixtures when a change in the composition of a mixture is among the components tested; production costs for a sub-system when a new component implies a change in these). Such special studies differ from case to case, but usually imply a rapid one-visit exercise (Table 1).

b. Choice of trial content

In the design phase, those who carried out the diagnosis interact with research specialists who may have solutions for the problems encountered. The target area is divided into provisional target groups of farmers ("recommendation domains"), problems are identified from the diagnosis and all the possible technical solutions to each problem are listed. At this stage it is useful to prepare a list of the technologies already available. The solutions are screened by technical and socioeconomic criteria. The research priority on-farm is then estimated by assigning weights to three criteria which summarize all the others: potential benefit, ease of adoption by farmers and ease of research. Easily researched and easily adoptable solutions to problems of medium priority may receive a higher priority for on-farm research than solutions to high priority problems which are less amenable to research and adoption.

A form has been designed to facilitate the operation by national program researchers of this process. Solutions which need medium-term work on technology development, be it on-station or on-farm, or which require a change in agricultural policy, are also identified. Emphasis is placed on working with relatively few technological components.

A second form is used as an aide-memoire for trial design. It lists the solutions and identifies probable interactions between them. This provides criteria for grouping in the same trial design, solutions which have a high probability of interaction. The urgency with which a solution is required and the confidence of researchers in the solution, also influence the type of farm trial designed (choosing between the five possibilities in Figure 1).

In the Bean Program's experience, the efficient grouping of solutions in different trials and the efficient choice of treatments corresponding to each solution are the most difficult parts to teach in the choice of trial content. We hope shortly to produce guidelines, so as to offer a procedure which supports "learning by experience".

c. Experimentation, interpretation and recommendation

Experimentation may be divided into the five stages shown in Figure 1, (viz: variety trials, exploratory trials, economic levels trials; verification trials, farmer-managed trials). These are described in their typical usage in Latin America in more detail in Table 2. Some types of trial may be eliminated, or conducted simultaneously, to simplify or speed up the process.

Variety trials are a specific pre-screening step to reduce the number of varieties tested on-farm. Their presence responds to the considerable importance of genetics as a solution to the problems of beans, a relatively undeveloped crop. The separation of farmer-managed trials from verification trials permits the evaluation on a semi-commercial scale of the compatibility of a single new technology with the farmer's system, and the farmer's ability to manage the technology. Apart from these sub-divisions, the trial types correspond with the three classes identified in the summary of the October 1984 meeting in Nairobi. These are

a) trials to determine which production factors are important from the short list produced during the choice of trial content,
b) trials to study at more levels those factors found important, so as to identify economic recommendations, and
c) trials to verify or validate more widely technologies composed of components identified as promising in (a) and (b) (IARC, 1985).

Economic evaluation is conducted for all stages from the economic levels trials onwards and can be useful in exploratory and variety trials. Analysis of budgets is the most commonly used technique. While computationally quite straightforward, success in applying this approach is dependent on the understanding of farmer objectives and constraints achieved during diagnosis. Whether farmer decision criteria are, for example, returns per hectare, returns to cash investment or yield stability, can critically affect the rank order of treatments. Cost data for use in budget analysis are obtained from cost of production surveys (Table 1). Whole farm programming or other modelling techniques are not used routinely for evaluation, their use being restricted to those few instances where there is a clear and pressing need for such an approach.

Farmer evaluations are also obtained at several points in the research process (Table 1). Interviews of farmers collaborating in trials can be of great importance both in clarifying what farmers like about the technical alternatives being tried, as well as in identifying management or other constraints to acceptance. For example, in the Great Lakes region, farm families evaluate, pure and in mixtures, the culinary qualities of the lines they have helped test on their farms. Farmer evaluations have been possible in many types of trial, but are most used in verification and farmer-managed trials. Collaborators in these trials are also interviewed after the cropping season following the trials. This follow-up measures the rate of spontaneous adoption and provides feedback on technology performance when it is completely in the hands of farmers without further contact of researchers.

The final farmer evaluation comes after formal release of new technologies through national research and extension systems. An adoption survey can identify constraints that may be hindering the spread of the new technology, as well as measure its acceptability and impact on farmers of different regions or resource bases.

d. Interface with extension

OFR bridges the classical divide between research and extension. In promoting the concept and practice of OFR, it is neither possible nor desirable to separate research from extension activities. Extensionists as well as researchers receive OFR training from CIAT, with the aim of integrating the two groups in OFR teams. CIAT is mainly active in the research aspects of OFR, but observes the whole process of research and extension and tries to ensure that suitable technologies verified by OFR are reaching farmers and being put into practice by them. The informal diffusion of technology from on-farm research trials provides an example of the blurring of research-extension boundaries and is described in section 6.

3.2 On-farm variety testing

On-farm variety testing (OFVT) is a simple strategy within OFR which draws on the same set of procedures. It is suitable where it is expected that a rapid, short-term impact may be made using the varietal component and, possibly some simple changes in agronomic practices. The suitability of varieties as solutions to farmers' problems has to be confirmed by the initial diagnosis. OFVT is aimed at a different group of potential practitioners, namely breeders and those of allied disciplines who are based on experimental stations. Such people usually represent the largest group of scientists working on the crop. In Latin America they are increasingly worried that the products of their efforts are not reaching farmers (CIAT, 1985b). The reasons have been lack of variety distribution to farmers (often because of lack of seed) and sometimes unsuitability of varieties for farmers' conditions. OFR could help with both but the researchers concerned cannot dedicate more than a proportion of their time to farm activities. They may also be deterred by the apparently wide focus of OFR, even when concentrated on a single crop.

OFVT originated as a suggestion from the invited participants to the December 1983 workshop on the future direction of OFR in the CIAT Bean Program. For the Program and its network of collaborators in Latin America, it responds to the need to test in a short time in a large number of environments the new bean lines becoming available. These have resulted from a strengthening of national programs in the last ten years in a previously neglected crop. Maybe because of this neglect, but also because of the low-input philosophy pursued by CIAT and its collaborators the varietal component in beans often makes an impact alone on farms, without any change in agronomic practices. The situation is very different in, for example, maize, where the history of plant breeding in the tropics is longer. In maize, it is unusual to obtain a response to variety under small-farm conditions without a corresponding change in agronomic practices.

OFVT is only recently taking shape in the plans of the Bean Program. Three years' collaboration on-farm with the national bean program of Costa Rica have been the first major experience. This experience was consolidated and extended more widely in Costa Rica and Central America by a recent course organized between CIAT and the Costa Rican Bean Program, with CATIE and CIMMYT support.

OFVT uses the procedures from OFR, and typically eliminates or combines a number of them. The present state of evolution of OFVT procedures in Costa Rica provides an example of the steps involved:

1. A simple reconnaissance and survey concentrated on farmers' needs which can be resolved genetically and on obtaining information about typical practices. If presently-available lines are unable to respond to these needs, the survey guides technology development rather than initiating OFVT. This also happens if agronomy rather than genetics is at present the only feasible solution to farmers' problems.

2. A screening of lines (maybe 6 to 16) suited to farmers' requirements and problems, under average farmer practices identified from the survey (equivalent to variety trials).

3. Trials of the best two or three lines under farmers' technology and one or two other technology levels identified from the diagnosis as promising changes (equivalent to economic levels trials).

4. Verification of the best technologies in more farms and with larger experimental plots.

Our experience is that diagnosis is not always the first stage to be accepted or established by researchers. When in place, however, it helps set future breeding priorities and not just identify suitable lines from among those presently available.

Occasionally step 2 might be eliminated if few promising lines are available but section 4 explains the dangers of this. Alternatively, step 3 might be eliminated when no changes in farmers' agronomic practices are identified as possible solutions to farmers' problems.

3.3 Technology development

In areas where suitable technological components are not at present available to overcome the constraints identified, technology development will be necessary on experimental stations. Some types of technology may, however, need to be developed partly or totally on farms. The concept of OFR for technology development covers research activities which are neither principally diagnostic in nature nor oriented to short term adaptation of technology to a specific location. It includes research which uses farms as research sites to develop new technologies that may be of broad applicability. OFR for technology development is a precursor to OFR for technology adaptation to specific areas (Figure 1). As examples, problems of soil fertility management and of soil conservation would require development on-farm. OFR for technology development may work on single components or on several interacting components. Thus it is sometimes more complex then "component research on-farm". It is however less ambitious than "new farming systems development" as defined by Simmonds (1984).

Sometimes the IARCs may have a comparative advantage over NARSs in the development of technology on-farm. An example is the development of prototype agroforestry systems with beans in Rwanda. Technology development on-farm may also become a normal activity of established national OFR programs. Because of this, the Bean Program is developing and testing procedures for these activities, which will later be passed to national programs. An example is the selection of large numbers of advanced lines or even segregating generations on-farm, and how to take the decision whether and when to do this. Another is the evaluation on-farm of the necessity of inoculating the bean crop with Rhizobium japonica.

3.4 Input to on-station research

On-farm research can greatly increase the effectiveness of on station technology development by gathering information on farmer problems, practices, resources and objectives as well as providing feedback about the performance of new technologies under farmer conditions. Due to the diversity of situations under which beans are produced even within individual countries, such information is of vital importance both to NAS and IARC's in order that on-station researchers pursue appropriate priorities and utilize relevant evaluation criteria. NAS must be responsible for the major part of this research, not only because they need information to guide their own on-station research, but also because they have a comparative advantage in this over the CIAT Bean Program, which has a large and diverse target area. Hence, Bean Program OFR activities emphasize methodology development, collaborative research, training and networking.

A variety of OFR activities generate information useful for orienting on-station research. This information is often a spinoff from technology adoption to specific areas. On-farm exploratory trials across a large number of sites can compare the importance, for example, of disease, insects and soil fertility as production limiting constraints. The results of a network of on-farm varietal trials can be used to refine selection criteria in breeding programs. Surveys and interviews with farmers can indicate what producers perceive as their most pressing problems, as well as clarifying the criteria by which they judge technologies. Such studies, for example, as examination of farmer preferences with respect to tradeoffs between yields and earliness, or grain types and yields, can help determine the relative priorities of alternative breeding objectives. The contributions of OFR in orienting on-station research are complemented by those of agroecological studies as well as regional or international trials.

4. ON-FARM AND ON-STATION RESEARCH

In contrast to some other IARC programs, the CIAT Bean Program does not develop new farming systems on-station. Disciplinary work, mainly selection of genetic materials, is conducted on-station in typical farmers' cropping systems and often at farmers' input levels. Despite this, recent work (CIAT, 1985c) has shown that the order in yield of elite lines on-station and on nearby farms may differ considerably, or be completely uncorrelated. This emphasizes the need for variety trials in OFR.

Other studies conducted by the Bean Program indicate that a similar lack of correlation may exist in the results of larger groups of advanced lines. Selection on farms of advanced lines (typically from 20 to 100 in number) is feasible and appears to be more reliable than on-station, although there are year to year variations in the relative performance of lines on-farm.

Even when near to the target zone and managed at similar input levels and in similar cropping systems to farmers' fields, experimental stations may be unreliable for predicting responses to other agronomic practices. It has often been suggested that studies of fertilizer rates and application methods, as well as manipulations of density and spatial arrangements, are better carried out on-farm from an early stage. Recent work by the Bean Program on station-farm comparisons confirms this. The topology and soils of the stations, as well as their former agronomic management, is thought to be responsible for the differences.

These recent results are leading the Program into suggestions for NAS and CIAT about which research activities should be conducted completely or partly on-farm. Procedures are also necessary for determining, for example, at what stages in a selection program genetic materials should be tested on-farm. The answer may differ according to the diversity of the target zone and the similarity of the station to farm conditions.

5. LINKAGES WITH NATIONAL PROGRAMS

The types of interaction which develop between CIAT and NAS's depend on the institutional context in each country. The first contact made by CIAT in a country is always with the NARS (National Agricultural Research Service), but when agreeable and useful to all parties, CIAT may work with other institutions. For example, development projects may provide a suitable environment for OFR in some countries. In others, OFR might first be conducted with members of a commodity research team and later expanded to include extensionists as well.

The final objective of OFR in the Bean Program is to have in place in NAS an OFR network which feeds back to station research and forward to farmers' adoption. Strong linkages are therefore maintained with NAS in all the OFR activities conducted. This is true for diagnosis, technology adaptation, technology development and training, which will be discussed in turn.

In OFR for diagnosis and technology adaptation, the Bean Program increasingly acts as advisor to national program OFR scientists, although the Bean Program sometimes takes a major share of responsibility for research design and execution in area-specific OFR, in order to obtain information about methodologies which are feasible.

Within the host country Colombia, technology development by the CIAT station-based breeding program is completely integrated with the national breeding program. The only difference is that additional materials of seed-types not acceptable in Colombia may be included under CIAT's responsibility. As technology development activities on-farm appear, these are also conducted collaboratively with the appropriate NAS. This was the case for the selection on-farm between ICTA-Guatemala and CIAT of the lines tolerant to Bean Golden Mosaic Virus (BGMV). These have now been released in several countries of Latin America. Besides BGMV tolerance, they appear to have a tolerance of poor fertility conditions and poor water balance which helps them outyield local cultivars even when the virus is absent. These tolerances presumably result from the selection of these lines under farm conditions.

Training of national program scientists now represents more than 50% of the time of the Bean Program's on-farm researchers in Latin America. OFR training courses at CIAT headquarters have been a major activity, but courses within countries or regions are increasing in importance. Two courses have been organized so far on a national or regional basis. Such courses are organized with partial financing by the NAS and in response to a direct request by the NAS. This places more of the responsibility for follow-up on the host national program.

The paper presented by CIMMYT has mentioned some of the important questions on how to institutionalize on-farm research. We would like to endorse their concerns about "whether systems-based research should be organized on a commodity or on a regional basis; whether it should be carried out by a separate program or through a liaison mechanism among existing programs and departments; whether it demands full-time practitioners or can be integrated (as in OFVT: our comment) into current research activities; what mechanisms will ensure interdisciplinary cooperation; and what ways to involve extension institutions in the work" (CIMMYT, 1985).

6. ACHIEVEMENTS AND FUTURE PLANS

The base of the CIAT Bean Program for self-education, methodology development and training in OFR has been Colombia. Since 1982, work has been conducted in collaboration with the national research and extension institution, ICA, in four contrasting ecosystems, each with a different predominant cropping system for beans. This built on previous work in technology validation conducted with ICA up to 1981. Through in-country and regional training as well as follow-up of former training participants, the OFR effort has now been expanded to other countries in Latin America. These include in particular, Peru and Costa Rica. At present, a strengthening of the activities in Ecuador, Honduras, the Dominican Republic and Mexico (in collaboration with CIMMYT) is in progress. These countries have been selected because a) they have new bean varieties, promising lines or other technologies for beans available; b) adoption is slow or non-existent or there appear to be errors in problem diagnosis; c) personnel are available to work in OFR and d) there is interest of the NAS in an OFR approach.

CIAT's regional strategy for bean improvement in collaboration with national programs in eastern and southern Africa has a strong OFR component. The Great Lakes Project is the first part of this strategy to become established and has been distinguished by the involvement of all project members in some on-farm work. Thus, the diagnosis of farmers' situation, problems and objectives has been used to set priorities in the research program.

In Latin America, achievements of the CIAT Bean Program's OFR work are now visible in methodology adaptation and development; in training; in feedback to the Program's activities in technology development; and in the demonstration of OFR procedures to interested NAS. These will be described in turn.

OFR procedures have been adapted and applied to beans, whether sole-cropped or multiple cropped. Strategies, including OFVT, have been designed and tested by combining the procedures according to the needs of different countries with which experiences in OFR have been shared. Differences, often drastic, have been shown in the order of genetic materials or agronomic treatments between station and farms. Procedures for dealing with station-farm differences when planning a research program are being designed, with NAS in mind.

A training strategy has been designed to communicate the procedures and strategies developed. Novel courses for OFR training include a three-stage in-country course in which participants execute OFR in their own regions between phases; a single-phase seven-week intensive course which makes use of established OFR in different areas of Colombia; and a two-week intensive course on OFVT. In the training effort, we have thus been comparing training strategies for OFR and intend to reach conclusions on their relative merits by the end of 1986. In addition, training serves as a meeting point for IARCs and other institutions to harmonize their methodologies. In Central America, the Bean Program is collaborating in training with CIMMYT and CATIE. In the Great Lakes region, an OFR course is planned between CIAT, CIMMYT, IITA and CIP. Seventy-eight Latin American scientists were trained in OFR between March 1984 and December 1985.

On-farm trials, surveys and farmer evaluations all provide important feedback to technology development and help adjust research priorities. For example, since OFR found that low soil fertility is a major constraint to production, the Bean Program has evolved more quickly towards resolving this limitation by breeding and selection. Additionally, climbing beans of great vigour, once thought to be inefficient in grain production, are now being selected once more due to their stability under infertile conditions on-farm. Studies of the adoption process of new varieties have generated further information on farmer objectives and persisting constraints. In Costa Rica and Guatemala, adoption surveys found that small farmers prefer the erect plant type of new varieties, even though their traditional varieties have been prostrate and sprawling. Adoption surveys in Costa Rica, Guatemala and Argentina indicated that most farmers are more aware of the yield potential of new lines than their increased yield stability obtained by improved disease resistance. The new varieties were usually accepted without changes in input use or cropping system, thereby validating the Program's low input philosophy. Unresolved problems have also been observed in these surveys. For instance, in Guatemala farmers continue to seek improved early varieties while in Costa Rica anthracnose remains a constraint. Cases of poor adoption of new varieties are also being examined. In Honduras and some areas of Colombia, marketing constraints have impeded the acceptance of novel grain types.

In order for OFR to be adopted and institutionalized within NAS, demonstrations of its effectiveness are necessary. The demonstrations must show that OFR produces benefits for farmers in a rapid and efficient manner. It must also be shown to unite researchers and extensionists and change their mentality. This demonstration has been particularly effective in the case of Colombia which will now be described.

In Colombia, benefits to farmers are already visible after three years' OFR in two of the four chosen areas. The most successful has been the Ipiales district of southern Colombia. In this area there are an estimated 10,000 ha of climbing beans grown in association with maize between 2400 and 2900 m.a.s.l. Farms are small, with 77% under 6 has in area. Beans are a cash crop in this district (94% of production marketed), as are potatoes, wheat, and barley, while maize is a subsistence crop. The maize/bean association is a particularly suitable small farm interprise in this system because a requires less capital and is less risky than potatoes, while creating more employment and yielding higher returns to land than wheat and barley. Although agrochemical use is widespread in maize/beans (over 80% use fungicides and over 50% use fertilizers), when collaborative OFR work with ICA started in 1982, mean maize yields were approximately 2000 kg/ha, and mean bean yields only 400 kg/ha. All the maize and beans grown were local cultivars. Over 70% of bean area was dedicated to a single cultivar, Mortiño, which has a very high commercial value (approximately US $1.75 /kg at farm level in the 1985 harvest). The principal problems amenable to technical solutions which were identified during the survey were foliar disease (especially anthracnose), root rots, low bean populations (necessary because the highly vigorous local bean cultivars tend to cause maize lodging) and the very long growth cycle of maize + beans (9 to 11 months because of the high altitude).

After three crop cycles of intensive trials, the line Ecuador 605 was released by ICA as "Frijolica 0-3.2". It had entered verification trials in the second year and farmer-managed trials in the third. The decision to release the line was guided by the observation that 40 farmers were already growing the line on a commercial scale during the third year of trials. They had obtained seed from trial borders, from neighbours who had trials, or by requesting the seed after observing the line in trials. The line also received favourable evaluations from farmers who had seen it in trials.

Farmers' observations coincided with those made by researchers, even though there had at that stage, been no attempt to explain the supposed advantages of the line. Farmers noted that it was higher yielding but of the same seed type and colour as Mortiño and could be sold alone or mixed; that it was tolerant to anthracnose and root rots; and that it was earlier to maturity. At present it is estimated that 400 farmers will plant Frijolica 0-3.2 in September-October 1985, and obtain yields 200-250 kg/ha above Mortiño, whatever the level of technology they use. Their maize yields will probably be depressed by about 100 kg/ha, due to the competition of beans. The bean:maize price ratio is however 5:1 at present and is usually above 3:1 in Colombia. Farmers accept the small loss of yield in their subsistence crop.

The OFR in Ipiales has thus produced results rapidly and there has been diffusion from the trials themselves of a technology which farmers identified as suitable. In addition, integration and mutual confidence has meant that ICA planted farmer-managed trials as soon as the technology was seen to be promising. They released the line one cycle later, after observing the progress of these trials, but without waiting for the harvest. The decision was also based on the results of previous small-plot and verification trials and on farmers' favourable reaction.

These are not the only lessons to be learnt from Ipiales. Table 3 illustrates that there is a continuous flow of new genetic materials from the experimental station to farm trials in response to farmers' needs. All the new lines have acceptable seed types, although different from Frijolica 0-3.2. At present the search is principally for a very early maturing bean of stable high yield and with disease resistance. ICA scientists are now preparing information so as to propose the release of TIB 30-42 which was identified during this search. In the search, some lines (not shown in Table 3) have been discarded after variety trials, others (like Llanogrande and 32980-1-41) have reached verification but have been found deficient and discarded. The technologies tested have not been exclusively new genetic materials. Table 4 shows the progress in the testing of other agronomic practices. The use of benomyl for improved foliar disease control has reached demonstration to farmers, after 2 years in verification because of doubts, now resolved, about the consistency of the benefit obtained. A change in the maize planting arrangement to increase bean density was rejected by farmers during verification, has been modified and is now once more in verification. Increases in fertilizer use and changes in maize variety have also reached verification for the first time in 1985-86.

Thus the experience in Ipiales is showing that OFR can produce a series of successful, adoptable technologies, and does not finish with the first success. The methodological question now being studied is how to determine when the marginal benefits of an extra year's work in the same area are lower than the benefits of commencing work with the same team in a new area.

A further benefit obtained from work in Ipiales has been a demonstration to ICA of the effectiveness of OFR at a time when the institution is incorporating an OFR perspective into its future plans, with help from CIMMYT, CIAT, IDRC and other institutions. We intend that the experience of CIAT with ICA in different areas of Colombia be consolidated in a comparison of the different strategies used within the basic methodology.

In this document, a number of the efforts presently underway in training and methodology adaptation have been described. We expect that these will provide further demonstrations to NAS in Latin America and Africa of the effectiveness of OFR. As such, they will contribute to the efforts of a number of IARCs which are working with the same goal.

CIAT sincerely believes that one of the more important developments in the future of its OFR will be an increasing collaboration with other IARCs. This will present a clearer message to national programs about the procedures and institutional organization of OFR, and maybe FSR in general. We hope that the present workshop will contribute to this goal.

We are grateful to CIAT colleagues for comments on the draft of this document, especially Scott Guggenheim, Raúl Moreno, Gustavo Nores, Aart van Schoonhoven and Carlos Seré.

REFERENCES

CIAT, 1985a. Integrated cassava projects. A strategy for development in cassava producing countries. Cassava Newsletter 9(1), 11-14, CIAT, Cali, Colombia.

CIAT, 1985b. Proceedings of the International Bean Trials Workshop, November 26-29, 1984. CIAT, Cali, Colombia.

CIAT 1985c. On-Farm Research. In Bean Program Annual Report for 1984. CIAT, Cali, Colombia.

CIMMYT, 1985. CIMMYT's approach to systems-based research. Paper prepared for the IARC workshop on FSR, ICRISAT, February 1986. CIMMYT, Mexico.

IARC, 1985. Summary and papers from an intercenter consultation on on-farm research in eastern and southern Africa, Nairobi, Kenya, October 18-20, 1984. CIMMYT Eastern & Southern Africa Economics Program, Nairobi.

Vera, R. R. & Seré, C. 1985. Evaluation of tropical pasture species with a farming system perspective. Paper presented to the XV International Grassland Congress, Kyoto, Japan, August 1985.

Simmonds, N. W. 1984. The State of the Art of Farming Systems Research. The World Bank, Agriculture and Rural Development Department, Washington, D. C.

Table 1. Survey activities used at present by CIAT Bean Program and its collaborators in Latin America[a].

Activity	Objective	Methodology	Person Days Required per Recommendation Domain	
			Field Work	Analysis
Analysis of Secondary Information	Compile existing information to orient survey and trial design.	Interviews with agricultural technicians and local officials. Literature review.	2-4	1-2
Reconnaissance	Obtain initial view of production zones and problems to select study area and modify exploratory survey.	Informal interviews and field observations, focused on bean enterprise.	2-4	1-2
Survey	Characterize bean production system and major constraints. Define recommendation domains. Orient trial designs.	Formal survey and field observations focused on bean enterprise. 25-50 farms/recommendation domain.	5-10	10-15
Special Studies	Achieve in-depth understanding of critical issues as identified in trials and previous survey work.	Dependent on information need as defined in previous research. For example, key informant interviews with farmers' opinions of a specific practice; survey of consumers/marketing agents; multiple visit surveys to measure flow of key variables (eg. spraying practices, labor/cash flows)	3-30	2-6
Cost of Production Surveys				
a) Beans	Derive cost data needed for economic analysis of trial results.	Single visit survey. 10-15 farms/recommendation domain.	3-5	2-4
b) Other crops	Estimate factor returns in other crops to set minimum criteria for new bean technologies.	Single visit survey. 10-15 farms/crop/recommendation domain.	3-5	2-4
Farmer Evaluation of Trials	Obtain farmer opinions of trial technologies and results.	Single visit interviews with farmers collaborating in trials.	3-5	2-4
Assessment of Spontaneous Adoption	Assess commercial use of technologies utilized in previous trials among farmer collaborators.	Single visit interviews with farmers collaborating in previous cycles of trials.	3-5	2-4
Adoption Survey	Measure adoption; identify adoption constraints of technologies under diffusion	Formal survey with random sample of farmers. 75-150 Farms/recommendation domain.	15-20	10-20

[a] Some types of survey activities may be eliminated depending on specific needs and resource availabilities.

Table 2. Trial designs used at present by the CIAT Bean Program and its collaborators in Latin America.

Type of trial	Commonly used experimental designs	No. of treatments	Typical plot site (m^2)*	No. of reps/farm	No. of farms/ recommendation domain
Variety	Randomized complete blocks (RCB)	Up to 16	5-16	2	3-4
Exploratory	RCB, often with factorial treatment structure. Split-plots or split-split-plots when chemical sprays are used.	Up to 16 Up to 16	5-16 5-16	1 2	4-6 3-4
Economic Levels	RCB or split-plots, sometimes with factorial structure.	6-12 Up to 16	8-32 8-32	3-4 2	3-4 4-6
Verification	RCB, sometimes with factorial structure	Up to 6 Up to 6	60-120 30-60	1 2	8-15 6-15
Farmer-Managed	Random position of farmer's practice and new practice	2	1000-3000	1	8-15

* Examples of plot size used in Colombia for beans in monoculture or associated with maize. May be different for other corps or farm sizes.

Table 3. Movement of promising lines in farm trials. Ipiales district, Colombia.

	Number of trials with the line included					
	Before 1981	1981-2	1982-3	1983-4	1984-5	1985-6
ICA Llanogrande	30 in another region	2	10V			
Frijolica 0-3.2		2	14	32V	40VM	40VM
32980-1-41			4	8	16V	4
Potosi 1			1	8	12	7
TIB 30-42				4	12	20V
V 8001					1	4

V: Included in verification trials

M: Included in farmer-managed trials

Table 4. Movement of other technologies in farm trials. Ipiales district, Colombia.

Technology	Before 1982	1982-3	1983-4	1984-5	1985-6
Addition of benomyl to farmer disease control	Successful in another region	6	12V	12V	8M
2 maize, 2 bean seeds every 0.5m	Successful in another region	6	12V	4	
3 maize, 3 bean seeds every 0.8m				4	16V
Increased use of fertilizers		4	4	4	16V
MB 521 maize		OBSN	4	4	16V
Pool 7 maize				4	4

V: Included in verification trials
M: Included in farmer-managed trials
OBSN: Observation in non-replicated plots.

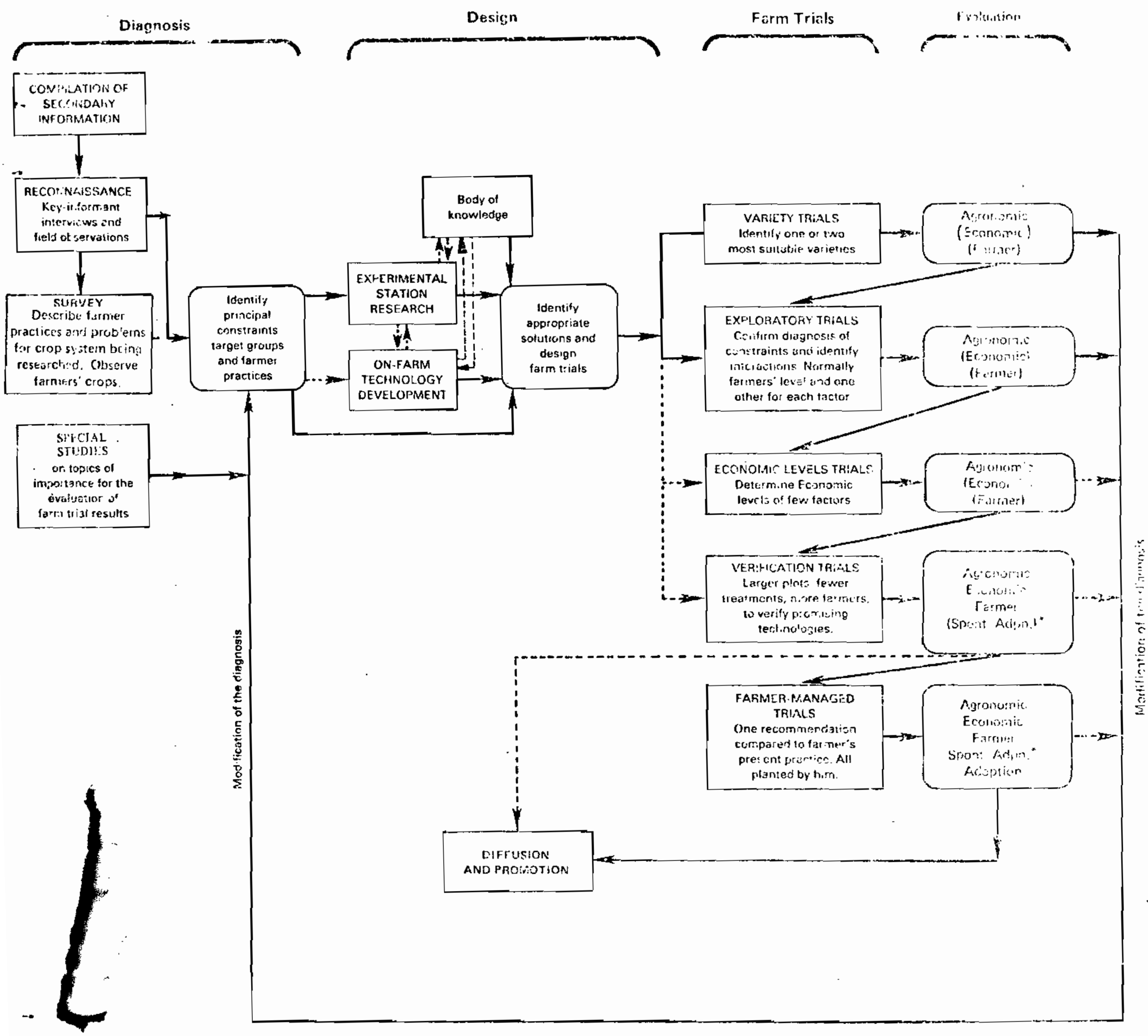

Figure 1. A conceptual framework for on-farm research being tested by CIAT and collaborators (Continuous lines show usual steps, broken lines show possibilities.)

* Spontaneous adoption by trial collaborators and adoption by farmers in general are measured at least one cycle after these trials.