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CREATING AN ON-FARM RESEARCH PROGRAM IN ECUADOR
The Case of INIAP's Production Research Program

Edgardo Moscardi, CIMMYT*
Victor Hugo Cardoso, INIAP
Patricio Espinosa, INIAP
Rómulo Soliz, INIAP
Ely Zambrano, INIAP

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* Joined University of Florida, mid 1982.
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PREFACE

The report which follows describes the evolution of a new research activity within Ecuador's National Institute for Agricultural Research (INIAP). The entity, the Production Investigation Program (PIP), concentrates on on-farm research. This report describes the research procedures which orient a part of Ecuador's PIP research effort. The research itself has certain distinguishing characteristics. It involves collaboration between biological scientists and social scientists (for the most part economists), it focuses attention on the needs of representative farmers, and it is area specific. The tone of the paper is one of advocacy as CIMMYT believes that collaborative, on-farm, area-specific research, focused on the needs of representative farmers, is an essential step in the development of effective technologies.

Ecuador is one of the countries in which the CIMMYT economics program staff cooperated closely with national researchers in on-farm research activities. Initial contacts were made in 1976 and, over the course of the next several years, both INIAP and CIMMYT made substantial commitments to the developement of effective guidelines for carrying out farm level-research. The experience in Ecuador was augmented by that in other countries where CIMMYT staff and colleagues from national programs were actively engaged in such research.

The essential elements of the process which emerged are: (1) the identification of potential research areas in terms of national priorities, (2) the delineation of tentative recommendation domains, (3) the organization of exploratory survey work, (4) the implementation of more intensive surveys where needed, (5) the pre-screening of information to identify leverage points for biological research, (6) the initiation of on-farm experimentation under the conditions of representative farmers and oriented by the survey process, (7) the adjustment of subsequent experimentation in terms of yearly results, and (8) the orientation of relevant experiment station research in terms of the findings from survey work and from on-farm experiments.

The following paper shows how the work in Ecuador evolved, how it has contributed to the development of improved technologies for the maize growers of two recommendation domains, and how the process has now been institutionalized by INIAP. We believe that the INIAP experience offers solid evidence of the utility of on-farm research. Beyond that, INIAP provides one model of how such research can be organized and administered within a larger research program.

The selection of areas and farmers for this study was heavily influenced by national research priorities, especially by a desire to commit few resources in a convenient area so as to limit the cost of testing a new process. The process itself is readily applicable to limited or extensive areas and, prudently managed, is cost effective in either case.

The paper is based on materials provided by the authors. These were edited by CIMMYT, with the edited copy then reviewed and corrected by the authors to arrive at the current version. Work on the paper started in early 1982. At that time Moscardi was CIMMYT's regional economist. Cardoso and Zambrano were agronomists working in the Imbabura region. Soliz and Espinosa, both economists, were the first and second directors of PIP.

Similar reports, based on the experience of other countries, will follow in the near future. We hope that these reports will encourage an ever wider application of on-farm research as decision makers see the utility of the process and the alternative forms for its implementation.

Donald Winkelmann
Director, Economics Program

CREATING AN ON-FARM RESEARCH PROGRAM IN ECUADOR

CROPS RESEARCH IN ECUADOR

Agriculture is the predominant economic activity of the Ecuadorian people. Approximately 43 percent of the national workforce is engaged in agriculture, which provides 21 percent of the gross domestic product and 40 percent of all export earnings. Yields of most food crops are quite low and showed little or no improvement during the 1970s. National Agricultural development goals focus on raising basic food production with particular concern for improving the welfare of small farmers, who dominate the agricultural sector in terms of numbers but not in terms of their contribution to national production.

The National Institute for Agricultural Research (INIAP), established in 1962, is charged with the organization and execution of a national research system to improve the productivity of Ecuadorian agriculture. INIAP has seven experiment stations throughout the country: four on the coast, two in the highlands, and one in the eastern Amazonian lowlands. Since its creation, INIAP has employed a typical research organization with various research programs and departments organized basically along disciplinary lines. Research programs (wheat, potatoes, maize, coffee, beef cattle, etc.) focus on genetic improvement; research departments (soils, entomology, pathology, agricultural economics, communications) play a supporting role as the different commodity-oriented programS develop improved cultivars and races of livestock. The research programs, supported by disciplinary research activities of the various departments seek to develop improved "technological packages" for Ecuador's major corps and livestock species.

Until 1976, INIAP scientists had been engaged in research at two levels: experiment station research and regional trials conducted in farmer's fields. Regional trials sought to test technological components--varieties and agronomic practices developed on experiment stations--under varying soil and climatic conditions at the farm level to determine yield potential and first approximations of production recommendations. Normally, these regional trials were placed on relatively large farms to assure adequate management and to obtain datA with reasonably high statistical confidence levels. Based on these regional trials, packages of recommendations were formulated and farmer field days were organized to extend recommended technologies to farmers.

Beginning in 1976, INIAP added a third level of research centered directly at the farm level. This research featured farm-level efforts to determine the production

circumstances facing farmers in different production regions and a series of on-farm experiments carried out on the fields of "representative" farmers under their conditions.

This effort was to aim at developing and verifying technologies appropriate to the needs of representative farmers. A number of factors prompted INIAP to expand its research system to include on-farm research. The over-riding concern stemmed from the fact that little impact on productivity was occurring from research on the basic food crops, particularly within the dominant small-farm sector. The absence of impact on basic food production led INIAP research leaders and others to question whether appropriate technology indeed existed for those basic food producers. Beyond that, it was asked if the current research approach could be expected to lead to effective technology for most of Ecuador's farmers. These apprehensions were particularly evident in highland maize and wheat production, where yields on the total area planted to these crops were either static or on the decline. Indeed, part of the initial interest of INIAP's leaders in on-farm research was motivated by their desire to ascertain the suitability of the Institute's existing recommended technologies for cereal production, particularly for small farmers.

DEMONSTRATIONS OF ON-FARM RESEARCH PROCEDURES

After discussion within INIAP, several highland farming areas were identified in which maize was an important crop and where small farmers occupied most of the land. Moreover, a range of biological and economic circumstances indicated that different technologies were required to serve the needs of different farmers in these regions. An area amounting to 50,000 ha in the provinces of Imbabura and Pichincha was selected as the first site to carry out on-farm research aimed at representative farmers. Although a wide range of crops were grown in the area, maize was a dominant crop in the farming system, covering 30 percent of the target research area. The preferred maize in this region had a large, soft, floury-type grain and was generally grown in association with climbing beans. The region was within the research responsibility of the Santa Catalina experiment station, which provided vehicles, equipment, inputs, and personnel services to the on-farm researchers. Funding was largerly supplied through a loan already made to INIAP by the Inter-American Development Bank (IDB). This was later supplemented by funds from the Swiss government.

By 1978, the importance of having the principal on-farm research staff live within the research area was recognized. Such a stationing at the local level represented a departure from the existing modus operandi of INIAP in which virtually all of the scientific staff were stationed at research stations located near the larger cities and towns. The funds

made available by INIAP/IDB to carry out the project permitted a special allowance to cover the costs of relocating the project staff and their family to the study area. The project staff also received additional compensation for them to work away from an INIAP experiment station.

The Survey Sequence

Scientists from the maize improvement program based at the Santa Catalina experiment station and from INIAP's department of economics, along with CIMMYT economics staff, began their research efforts in 1976 by travelling in the area and talking with farmers and store keepers and others about the various problems associated with maize production and marketing within the region. New information generated by this "exploratory survey" combined with the existing knowledge of INIAP's maize scientists about production problems in the target research area led to a preliminary delineation of major agroclimatic zones and farming systems. This was a first step toward the formation of recommendation domains, and the tentative identification of key questions and hypotheses for a formal survey questionaire to be administered to a random sample of farmers in the area. Six recommendation domains were tentatively identified in the study area using criteria such as altitude, precipitation, and soil type. Aerial maps from Ecuador's Military Geographic Institute with a scale of 1:50:00 were utilized to randomly select the land parcels and farmers for this survey. A random sample of 230 farmers was identified and interviewed.

The questionaire focused on issues related to maize technology along with immediately competitive and complementary activities and sought to identify research opportunities to increase the productivity of farmer resources. Farmers were asked questions clustered around eight groups of variables:

1. cropping patterns and practices;
2. storage practices;
3. consumption;
4. crop marketing and input adquisition;
5. agroclimatic characteristics of the area;
6. socioeconomic characteristics of farm units;

7. significance of institutional factors, such as access to information and technical assistance on production practices; and

8. an evaluation of farmer preferences for earlier-maturing maize varieties.

Two teams of interviewers (two scientists per team) were organized to undertake the formal survey. The interviewers were first-degree agronomists (agricultural technicians) who first received three weeks of training before beginning their formal survery work at the Santa Catalina station in survey procedures and in the production and physiological aspects of the floury maize crop. In a period of roughly two months, these technicians completed their interviews with the farmers selected for the survey.

INIAP's department of agricultural economics staff did the coding of the questionaires and the data were then analyzed at CIMMYT, Mexico using computer programs developed to analyze such survey information. A report on the conclusions of this survey activity, titled "Production Practices in Ecuador," was prepared in 1977. This report provided a statistical analysis of the groups of variables included in the survey questionaire.

A second survey was undertaken in 1979-80 to re-examine a number of the factors originally considered in the 1976 survey. In particular, maize prices, marketing patterns, input prices, and nutritional issues were re-examined. Results of this survey reconfirmed the importance of maize for home consumption, identified several quality issues related to local preferences for white and yellow grain for different food products, and reconfirmed that farmers were highly interested in early-maturing maize and bean varieties that would allow for an intensification in cropping patterns.

Delineation of Recommendatation Domains

Data from the informal and formal surveys confirmed that the two provinces contained at least six different recommendation domains. As each recommendation domain would require on-farm experimentation and research resources were scarce, it was decided to concentrate attention on the three domains found in the Imbabura province. About half of the respondents from the survey were located in these three recommendation domains and maize was particularly dominant in their farming systems.

Considerable agroclimatic variation existed among the 112 farm surveyed in Imbabura. While some differences in

economic characteristics were identified, biological factors remained dominant in the delineation, and soil type were the major criteria used in their formation.

Recommendation Domain	Average Altitude (meters)	Average Precipitation (mm)	General Soil Type
Ibarra	2,300	650	Clay
Cotocachi	2,350	700	Sandy
Otavalo	2,500	855	Loam

Other factors also were considered in the delineation of the three recommendation domains, e.g., the proportion of level land, availability of supplemental irrigation, incidence of pest problems, and whether maize was grown as a monocrop or in association with climbing beans. Table 1 describes a number of the circumstances and practices of farmers in the three recommendation domains.

Prescreening Components for On-farm Experimentation

Based on the anylisis of the survey information for each recommendation domain, researchers identified key factors as relatively more important for investigation in the on-farm experimentation phase. The importance of variety to the farmer was particularly clear. The preference expressed for earlier-maturing maize varieties cut across all three recommendation domains. Only in Otavalo, the area with the best soil, flattest lands, and highest moisture, was there a lower preference for earlier-maturing varieties. However, even in Otavalo 65 percent of the respondents were interested in obtaining short-season varieties. For the three domains, 80 percent of the respondents signaled a strong preference for shorter-season varieties suitable for a maize-climbing bean association and which could allow for the introduction of an additional short-season crop (such as peas or chickpeas) into the cropping pattern.

Of the respondents who named early-maturity as a desired varietal characteristics, 60 percent also said that they would be willing to sacrific some yield in a variety that could shorten the growing cycle by four to five weeks. Maize breeders used this information as a selection criteria for maize varieties to be tested in the on-farm trials. Breeders sought to identify improved varieties that were 30-40 days earlier-to-maturity than traditional varieties and that yielded within 80-85 percent of the available long-season varieties.

Insect control was a second potential element considered by the research team as they pre-screesed

Table 1. Important circumstances identified in the Imbabura province farm-level survey, 1977

Recommendation Domain	Farmers Surveyed	Average Area in Maize (ha)	Maize in Assn.	Use Organic Fertilizer	Use Chemical Fertilizer	Sell Maize	Off-farm Employment	Preference for Earlier Maturity
			-------- percent of farmers --------					
Ibarra	53	1.17	93	75	2	10	60	90
Cotacachi	33	1.46	70	40	-	11	35	85
Otavalo	26	2.40	100	35	8	40	33	65

possible technological components to be included in the on-farm trials. Although most of the survey respondents said that they had problems with insects (mainly corn ear worm), most did not consider insect damage a major problem. Using the survey data along with the information from the department of entomology at Santa Catalina station, it was estimated that the use of an insecticide to control corn ear worm could increase yields by at least 15 percent. With the existing average yield of 1.5 t/ha, such control would result in a yield increase of 225 kg/ha of grain. Although this estimated benefit from insecticide use was conservative (e.g., with the simultaneous use of other inputs such as fertilizer and improved varieties, the impact on grain production of using insecticides would probably be higher), the research team calculated a criterion to evaluate the different insecticide treatments in multifactorial trials included in the on-farm experimentation phase. Assuming a need for a 25 percent return to investment to cover capital costs and risk factors associated with chemical control of insects, it followed that acceptable insecticide treatments should have an equivalent cost per hectare of 180 kg of grain or less to be attractive to representative farmers in the region. This finding guided selection among alternative insect control strategies.

A third element considered during the pre-screening process was fertility. With many farmers using manure and few applying chemical fertilizer to maize (although many were applying it to potatoes), the possibility for increasing productivity through the use of chemical fertilizer was evident.

Weed control was a fourth element considered. Many farmers used weeds to feed "cuyes", a small animal raised for sale and for meat. The question was, how did weed control affect yields and what would be implied for meat production.

In addition to the examples described above on how survey data were used to prescreen priority technological components for on-farm trials, the survey also provided the research team with information on the most common (representative) cultural practices employed by farmers in the three recommendation domains. Through the survey sequence, researchers knew how farmers planted their maize, how they fertilized their crop, and how they controlled their weed populations. They knew about planting dates, rotations, the equipment available, and common uses of maize. These findings identified representative farmers, set the levels for non-experimental variables, and influenced the levels over which experimental variables ranged.

Selection of On-farm Trial Cooperators

Data from the survey were next used by INIAP researchers to identify a number of on-farm trial sites which were representative of the agro-economic conditions in each recommendation domain. Survey respondents had been asked whether they were willing to collaborate in on-farm trials through the contribution of a small amount of land and labor for experimental purposes. A surprising number had indicated an interest in participating. Consequently, researchers already had a list of interested cooperators from which to choose. The survey had indicated that representative farmers in Imbabura grew their maize in association with beans. Beyond this, representative farmers prepared their fields with oxen, used manure if they fertilized at all, typically sold only a small portion of their product at the market place, and were involved to a considerable extent in off-farm employment. These factors were explicitly considered in the selection of collaborating farmers for the subsequent on-farm trials and established the levels at which non-experimental variables were fixed.

Initiating On-farm Trials

With the survey data analyzed and discussed by biological scientists and economists, and with the priority research issues related to early-maturing varieties, fertilization, and insect and weed control identified through the "pre-screening" activity, the INIAP on-farm researchers initiated their first series of exploratory trials on farmer's fields.

Since farm-level trials (e.g., regional trials) were not new at INIAP, the director general of the institute called a meeting of interested staff to explain that one objective of the first round of on-farm trials in the Imbabura on-farm research project would be to validate, economically and agronomically and under representative farmer conditions, the technology already available and recommeded by the Santa Catalina station staff for the area. Consequently, validation of available INIAP technology, as well as actual technology generation, per se, was set as one goal of the first cycle of trials.

Four different types of trials were designed for the Imbabura on-farm experimentation phase, initiated during 1977-78, and carried forward in subsequent years. These included variety trials originally with maize, beans, and later peas and lima beans; multiple factor interaction trails to identify critical interactions among management factors associated with maize production; fertilizer levels trials to identify appropriate fertilization recommendation; and verification trials to evaluate potential technology

recommendations identified through the on-farm research. Because of the interest in evaluating existing INIAP production recommendations, technology verification experiments, in addition to exploratory research trials, were undertaken from the outset. Descriptions of these experiments follow.

Variety Trials

Maize variety trials were carried out in the three recommendation domains during the first two years of experimentation. Five maize varieties plus the farmer's variety were included in these trials. Of the improved INIAP materials, two were long-season varieties and three were short-season varieties. In all cases, maize and beans were grown in association. Table 2 shows the results of the variety trials grown during the first cycle of experimentation in two of the three recommendation domains. The three short-season varieties included in the trials had acceptable grain types (both white and yellow) were 45-55 days earlier-to-maturity than the farmers' traditional long-season varieties, but within the range of yield acceptability previously determined by the survey, e.g., within 15 percent of the yield level of the local variety. It was also apparent that the local climbing bean varieties tested were too aggressive for the earlier-maturing maize varieties, knocking them down with resulting yield losses. The long-season improved maize varieties (INIAP 125, INIAP 126) were not significantly higher in yield performance than the farmers' local varieties.

In the second cycle of experimentation, INIAP's grain legume program staff provided eight short and long-season bean varieties that were less aggressive in their vegetative and climbing characteristics than the farmers local varieties. These, then, were included in the variety trials of that year. An important feedback from the cooperating farmers was that yield potential (largely a function of disease resistance) was much more important to them than grain type and color.

The major conclusions from these varietal trials was that early-maturity was a major requirement of many farmers in the various recommendation domains. Further, the earlier-maturing white floury variety, by then named INIAP 101, had been enthusiastically received by farmers. While some grain quality problems had been identified with this variety in the preparation of mote (a type of hominy), one of the uses of white grain maize in the area, and in the greater susceptibility (compared to local varieties) of INIAP 101 to stored-grain pests, it was apparent that the agronomic qualities of early-maturing maize were highly desired by local farmers. This fact meant that INIAP should contine research to develop such varieties.

Table 2. Yields obtained in the 1977-78 variety trials in two recommendation domains

Domain	Long-Season Varieties			Short-Season Varieties		
	Local	INIAP 125	INIAP 126	INIAP 101 1/	Comp. Am. Harinoso	Comp Ccacahuazintle.
	t/ha					
Ibarra (two trials)	1.95	1.45	2.20	1.50	1.91	1.60
Otavalao (one trial)	3.50	1.65	2.00	2.85	2.25	3.70

1/ Reselection made by INIAP from a Cacahuazintle composite variety originally developed in Mexico and later named INIAP 101

Among the long-season varieties, INIAP 126 showed promise for the Cotacachi recommendation domain. The maize variety, Varios x Chillos, an intermediate maturity, yellow grain material included for the first time in the second year of trials, performed favorably at a number of locations. However, the lack of uniformity, particularly with respect to maturity, resulted in feedback to experiment station researchers on the need for further improvement before it was ready for release to farmers. On the other hand, the performance of the variety INIAP 125, a long-season yellow grain variety, was unsatisfactory for two years in a row. This information was communicated to scientists at the Santa Catalina experiment station, and resulted in the removal of this material from INIAP's list of recommended varieties.

Based on the trial results with respect to climbing beans, the Santa Catalina legume improvement staff began to intensify their work to develop a broader range of earlier-maturing bean varieties with adequate levels of disease resistance.

Multiple Factor Trials

These trials served to identify critical management factors in maize production, their order of priority, and their interactions. A factorial design (2^4) was used in these trials and the interactions among the following four factors were studied: varieties, weed control, fertilizer, and insect control. In such trials, two levels (low level - high level) are used for each factor (e.g., the farmer's level of fertilization, INIAP's previously recommended dosage; the farmer's variety, and INIAP improved varieties).

The results of the multiple factor trials prompted considerable discussion between the on-farm research team and scientists at the Santa Catalina station, since recommended technologies only showed small positive biological responses over the farmers' technology. For example, the "complete" recommended technological package showed responses up to 1 t/ha over the farmers' technology and the "non chemical control" recommended technology only showed reponses of up to 0.5 t/ha over the farmers' technology. However, when the various treatment combinations were submitted to economic analyses, they were generally found to be only minimally profitable in each of the three recommendation domains. Only in Otavalo, the most favored environment of the three recommendation domains, was there a substantial interaction and economic return from the combined use of the recommended varieties, fertilizer rates, and cultural practices. Interactions among the factors in the factorial trials grown in the other recommendation domains did not appear to be economically significant.

The weed control treatments included in these trials showed that the chemical herbicide mixture used in the maize/bean association gave control for less than four months before an additional hand weeding was necessary. The need for additional weeding to achieve adequate control made the use of chemicals unprofitable, given the cost of herbicides and the existing wage rate for hand weeding. An economic sensitivity analysis applied to these data indicated that the cost of hand weeding would have to increase by 80 percent before chemical control could be recommendable. In response to this analysis, scientists from the department of weed control began studies to improve the effectiveness of herbicide use. A number of off-station trials were conducted to evaluate different application methods, such as banding, in order to reduce the costs and improve the benefits associated with the use of herbicides for weed control.

A similar situation was observed in the case of insect control, especially for corn ear worm, the major insect pest in the research area. The recommendation for corn ear worm control (which was used as a treatment in the factorial trials) was the application of an insecticide four times to the ear silks using a backpack sprayer. However, the yield advantage of this practice was not substantiated in the factorial trials. Follow-up discussions with technicians who carried out the recommended treatment in the on-farm trials revealed that it was difficult to carry out insecticide applications with the backpack sprayer when the maize/bean crop stands were as tall and dense as they were at the recommended period for treatments. The result was that an insufficient amount of the active chemical agent reached the stigmas of the ears. As a consequence of this observation, the entomology department began to test other application methods in order to determine whether a more simple insecticide application method could be developed which could give more effective control with smaller doses of the active agent than was possible with the previous method.

Fertilizer-Levels Experiments

These experiments serve to identify economic levels of fertilizer use. The trials included various varieties and levels and combinations of fertilizer nutrients and recommended application methods. Other management practices were set at the levels normally used by the farmer. Only in the Otavalo recommendation domain was an experimental treatment (20 kg/ha N, 20kg/ha P_2O_5 plus organic fertilizer) more profitable than the farmers' check treatment which only included the application of organic fertilizer (manure). By estimating the nutrients contained in the organic fertilizer dosage, profitable application rates were determined to be in the range of 50-80 kg/ha N, 20-40 kg/ha P_2O_5. Based on this series of trials, it was decided to set the general

fertilizer recommendation when using improved varieties (local varieties did not show an economic response) at 80-40-0 for subsequent verification trials.

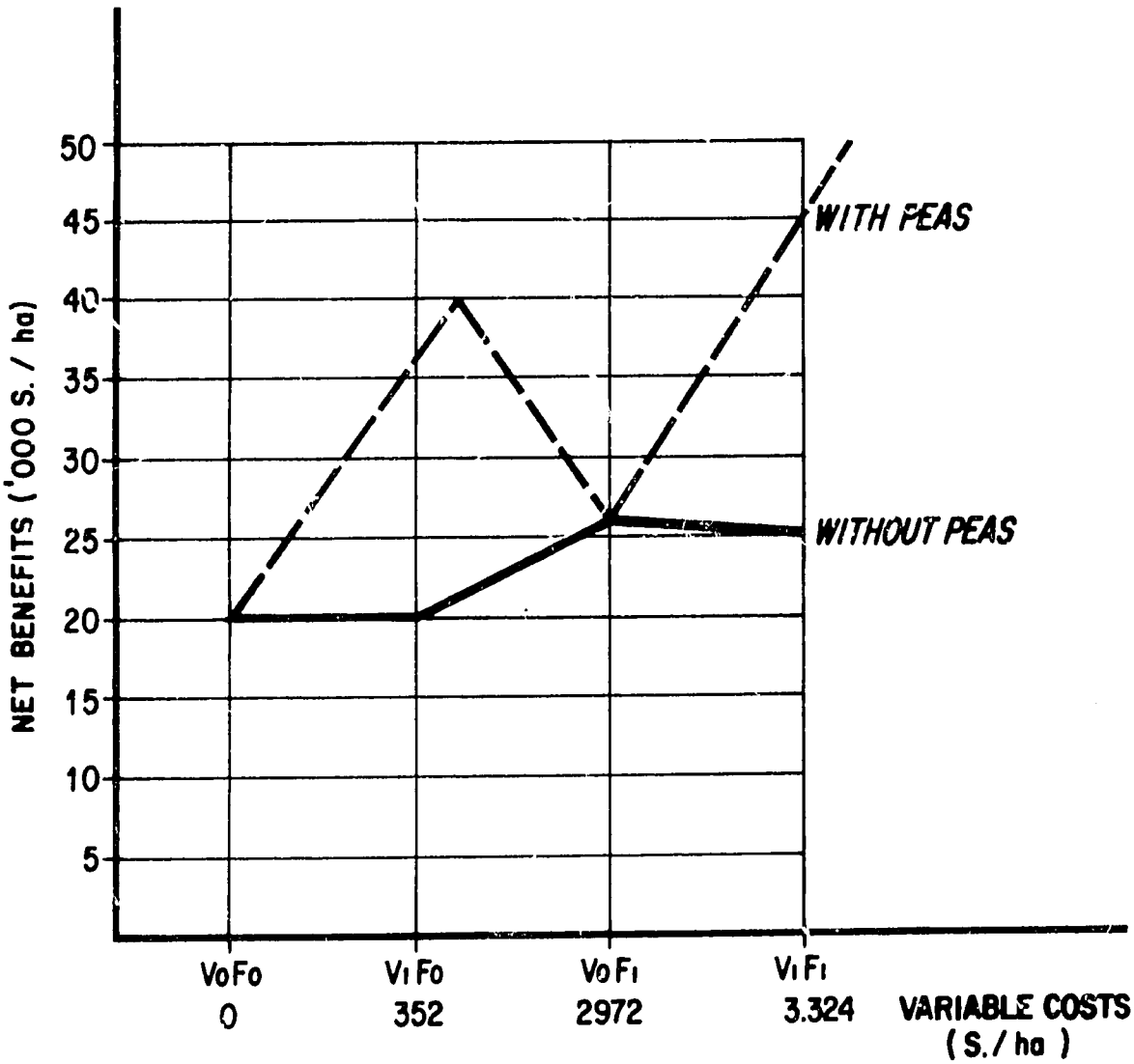
Verification Trials

The purpose of these experiments was to validate the technology presently recommended by INIAP as opposed to current management technology and varieties of the farmer. Results from these verification experiments, as well as information on farmers reaction to the different technologies, provided feedback to INIAP's experiment station researchers on currently-available technologies. Since verification trials are designed to evaluate a relatively few number of treatments (technologies) for their suitability for commercial production, larger plot sizes are used than in factorial and fertilizer levels trials and the farmer provides almost all of the management.

The research activites in the third and fourth cycles of on-farm experimentation were primarily focused on the verification of the results obtained from experiments the first two cycles. A series of verification trials were conducted in the three recommendation domains. The results of the first two years of on-farm experimentation had led researchers to believe that at least for the Otavalo recommendation domain, the use of the short-season variety INIAP 101 fertilized at 80-40-0 offered farmers a significant economic return. Consequently, farmer field days were organized to view the verification trial results and the diffusion process for this recommended technology began. In the Cotachachi recommendation domain, characterized by sandy soils, a longer-season maize variety, INIAP 126, showed good yield potential, especially when nitrogen was applied.

For the Ibarra recommendation domain, no clear recommendation had emerged from the first three years of experimentation. Therefore, the majority of the experiments in the fourth on-farm experimentation cycle were centered in Ibarra. The most promising variety for the Ibarra area was the short-season yellow grain variety Varios x Chillos. Although this variety had a lower yield performance (3.15 t/ha) than the local check, it was in the same maturity range of INIAP 101, and thus offered the potential for double cropping. Figure 1 shows a net benefit curve derived from the 1980-81 verfication trails conducted in Ibarra. When looking at the full farming system, the net benefit to the farmer of using short-season maize and bean varieties becomes significant because it brings the option of intensifying the cropping cycle. When an additional crop is added to the annual cycle, in this case peas, the annual returns to labor and capital are significantly higher than when the returns to the short-season maize variety are

Figure 1. Curve of net benefits in verification trials for Ibarra recommendation domain, with and without peas 1980-81



V_o = local variety

V_1 = INIAP 101

F_o = farmer's fertilizer practices

F_1 = INIAP recommended fertilizer application (80-40-0)

viewed in isolation. (Benefits for peas were confirmed during the 1981-82 cycle.)

Continuing On-farm Experimentation and Technology Transfer Activities

For the 1981-82 crop production cycle in Imbabura, on-farm researchers directed their efforts toward three sets of activities: demonstrations and technology transfer associated with the use of the short-season maize variety INIAP 101, a continuation of on-farm trials emphasizing new activities associated with legumes and various other crops planted in rotation with maize, and special studies to monitor the acceptance and derived benefits from the recommended technologies extended to date.

A promotional plan to distribute small quantities of seed of the short-season maize variety INIAP 101 was developed by the PIP research staff. INIAP's director general then contacted the national seed production organization (Empresa Mixta de Semillas) to provide two tons of INIAP 101 seed packaged in 10 kg bags. Eventually, 150/10- kg bags were provided and these were sold to interested farmers through Ministry of Agriculture offices, mostly in Otavalo. A limit of two bags per farmer was set and approximately 80 farmers bought the available seed. A simple promotional brochure was prepared to explain INIAP recommendations for using INIAP 101 in association with beans. Farmers were advised to use the least aggressive climbing beans varieties they could obtain, their own planting density, and fertilizer if they could get it. In order to monitor how these participating farmers took advantage of the "earliness" of INIAP 101 (e.g., what they did with the extra days available for other crops and farm activities), a sample of 30 farmers was selected for follow-up surveys (results not available in mid-82).

In addition to these technology transfer activities, a new cycle of on-farm experiments was planned for the three recommendation domains in Imbabura. A total of 21 trials, equally distributed across the three recommendation domains, were planted, including new variety trials to evaluate recently developed short-season maize and bean materials emanating from the Santa Catalina station crop improvement programs. The increasing availability of these short-season maize and bean materials has resulted from new emphasis in the breeding priorities of the maize and grain legume improvement programs at the Santa Catalina station.

A number of new special studies were also included in the 1981-82 on-farm research cycle:

1. A study was initiated on production problems of broad beans, a crop of secondary importance often

grown in association with maize, and which is heavily afflicted in Imbabura by disease and insect damage. This crop has a maturity period that also allows it to be used in rotation with the short-season, maize-bean crop association. A series of verification trials were also planted in conjunction with the department of entomology and pathology to evaluate the effects of the pest and disease problems in broad beans.

2. Long-term fertilizer evaluation trials were initiated to study the effects on soil fertility of the crop rotation pattern of a maize/bean association followed by peas. The objectives are to develop a fertilizer recommendation for this crop rotation sequence, and to quantify more explicitly the economic returns of the maize/bean-pea rotational pattern.

3. New verification trials were planted at the request of the Santa Catalina entomology staff to re-evaluate the economic utility of the ear worm control methods formulated by the department of entomology.

4. Several experiments on methods to reduce grain losses from stored-grain pests were also under way, again at the request of the departments of entomology and agricultural engineering. In these storage experiments, the effectiveness of the department's recommended grain treatment (1% Malathion) is being evaluated under farm-level storage conditions.

5. A more systematic method of market data collection in Imbabura was also added to the work as responsibilities of the on-farm research team. This information will now be collected on a regular basis for use in production cost studies conducted by INIAP's department of agricultural economics.

Additional Comments on the On-farm Research Experience in Imbabura

Several additional points need to be made about the on-farm trials conducted in Imbabura Province during 1977-82. The first is that, throughout the process, station-based and off-station researchers collaborated in designing trials and in interpreting results. Specialists from the maize improvement program and the economics department at Santa Catalina oriented the early on-farm research work in Imbabura. They were soon joined by station

specialists from other departments. Always, of course, the guiding principle was the farmer's requirements, and these were the points of departure for interaction the INIAP researchers. Later, with the formation of the PIP (see below) this collaboration took in a somewhat different form.

For the most part, the trials were managed by farmers. Only those activities directly related to the experimental variables included in the initial exploratory trials were managed by the researchers. A second point is that the researchers, themselves, learned by doing, refining their methods over the years. The case of planting densities is a good example. At the outset, planting densities for variety trials were set at the level of the "average" for the recommendation domain. As the work progressed, researchers noticed that, while the average stand densities of cooperating farmers approximated the original averages estimated during the survey phases, there seemed to be systematic differences among the cooperating farmers. More careful observation showed that plant stands were closely related to fertility, even within a recommendation domain. While this variation was not large enough to warrant the delineation of new recommendation domains, it did induce researchers to adopt the practice of working alongside each trial cooperator during the planting stage so that the plant stand in each trial varied as did that of the farmer in his normal production fields.

From year-to-year, about 40 percent of the trials were lost due to a number of factors. Drought, in particular, was a serious problem in a number of years. Supplemental irrigation systems also turned out to be an unexpected problem. The 1976 survey sequence had revealed that 40 percent of the farmers interviewed had access to some form of supplemental irrigation. Consequently, about 40 percent of the on-farm experiments were situated on similar fields. Many of these trials, however, were eventually abandoned. Upon closer examination, the research team found that the supplemental irrigation systems on these lands were so deficient that they were almost totally inadequate for irrigation purposes in seasons of unusually low rainfall. Trials were also lost due to causes other than drought. Such losses occured because of theft of early-maturing maize at the green cob stage, problems of land tenure of the cooperator, and bird and livestock damage.

The high number of trials which were "lost" during the on-farm experimentation cycles was a matter of great concern to some researchers at the Santa Catalina experiment station. Further, there was considerable concern about the high coefficients of variability in the data obtained from those trials that were harvested. Very few trials had statistical confidence intervals at the 95 percent level. Rather, the confidence intervals in most trials were in the

75 to 90 range, considered very low by experiment station standards. These factors led to strong doubts among some INIAP researchers about the utility of cooperating with representative farmers, about the cost-effectiveness of this type of on-farm research, and about the confidence one could place in the results.

The on-farm researchers contended that the loss of trials and the lower statistical confidence intervals were the real costs implicit in any attempt to obtain valid information at the farm-level on the performance of alternative technologies. With respect to statistical confidence levels, they held the position that in research to formulate production recommendations, the critical determination to be made was whether the various technologies under investigation increased the net benefits to the farmer within acceptable risk levels. Such determinations, they contended, could be made using on-farm trial data ever with higher coefficients of variability. No concensus was reached amoung the INIAP researchers engaged in this debate regarding these diverging points of view.

INSTITUTIONALIZATION OF ON-FARM RESEARCH WITHIN INIAP

INIAP's current national production research program, formally established in 1979 (known by its Spanish acronym, PIP), can trace its origins to the Imbabura project and to an Inter-American Development Bank (IDB) loan made to Ecuador for INIAP in mid 1977. This US$11 million dollar IDB loan, along with US$5.9 million from the Ecuadorian government, and additonal funds from the Swiss government in 1978-79, provided INIAP with funds to reinforce the institute's on-going research programs as well as to establish a production research program focused on the small farmers of the country. Few details about the form this production research program should take were spelled out in the original loan document, except that a "system of technology transfer will be introduced through specialists in production."

In 1977, during the initial phase of the new Ecuadorian effort in on-farm research, it was considered desirable to obtain experience with several production systems for important food crops in which Ecuadorian production was deficient or had the potential for expansion. The existence of previous research and the availability of results that might be used in the program were also taken into consideration in selecting research priorities. Originally, maize, wheat, rice, potatoes, and dairy production systems were selected for on-farm research attention. Similar research projects for other important

Ecuadorian crops and livestock systems were soon launched in other small-farmer areas of the country.

Creation of the National Production Research Program (PIP)

As results from the on-farm research emerged, INIAP leaders were thinking about alternative ways to institutionalize the activity. Although INIAP's existing organization structure worked well in the development of some technologies, it was not at its best when research activities around of complex production systems had to be integrated, as in the case of Imbabura with various associated and multiple croping patterns.

In 1979, INIAP decided to establish the national Production Investigation Program (PIP) with its own personnel especially trained in the on-farm research procedures previously described (see figure 2). An early document about the newly created PIP defined its objectives in the following way:

Definition: PIP is a technology transfer program for the investigation of production constraints and production opportunities on farmers' fields and focuses on farming systems.

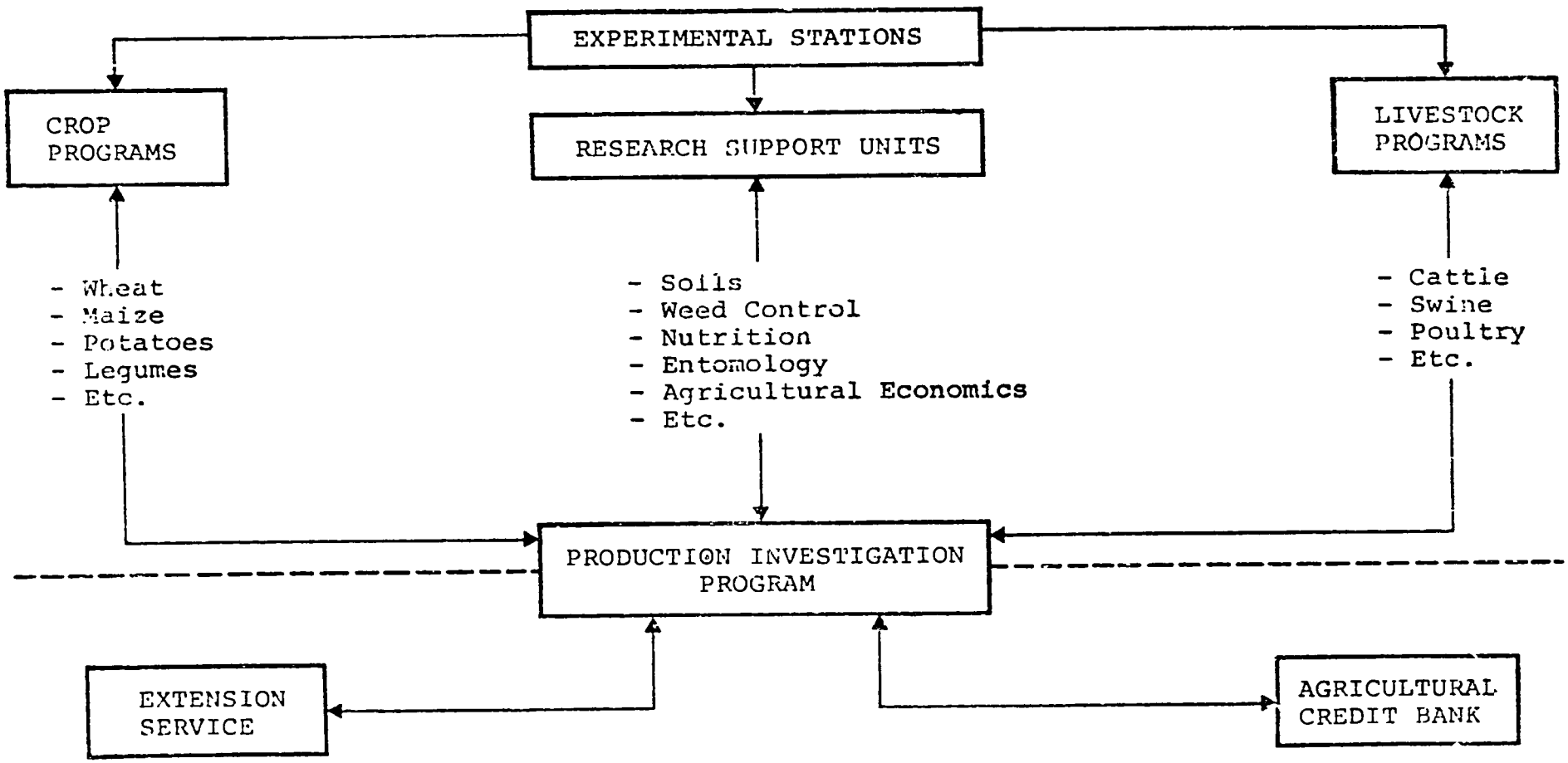
Objectives:

1. Screen and test on the farmer's own field those technological components that are being generated in the research support departments and crop programs of the experiment stations, for immediate adaptation or adjustment to the principal farming systems of a region.

2. Provide farm-level feedback which will orient and guide the research which is being carried out at the experiment stations. This feedback will give rise to the development of new technological components which respond to problems and limiting factors detected among the farmers of a region.

3. Formulate alternative technologies, subject to economic validation, which can be made available for subsequent technology transfer by the extension service and agricultural credit agencies.

Figure 2. Structure of the Production Investigation Program (PIP) within the overal INIAP structure



By 1980, PIP production research programs were under way in 10 major production environments and ecological regions of the country with 18 on-farm researchers directly assigned to the program (see table 3). These included PIPs for the lowland Pacific coastal areas, the Andean highland valleys, and the piedmont areas of the Amazon basin.

A key manpower deployment characteristics of the PIP program has been that the production researchers live in the region selected for their research so that they can establish close contacts with local farmers and with the community, and above all, so that they can obtain a better perception of the most important production problems and research needs facing area farmers. Researchers assigned to each PIP are provided with vehicles and fuel for travel in the research area. Other inputs needed for the trials are supplied by the various INIAP experiment stations which support each PIP project area. A special incentive system also has been established for the PIP researchers, with the salary depending on geographic location, stipends for living expenses, and the same opportunity as experiment station researchers for postgraduate studies after two or three years of service. The interest of young INIAP personnel in the PIP has been extremely high.

The introduction of a new level of agricultural research into an established institute, especially an adaptive research program with cuts across different crops, research disciplines, and agricultural organizations, is not without its institutional difficulties and frictions. Frequent coordination meetings are necessary with the staff of the commodity programs and research support departments to establish and review goals, objectives, and strategies, and to determine the respective responsibilities of the production research teams and the experiment station investigators.

The steady interest and participation of the experiment station research leaders is also of great importance for the success of a program such as the PIP, since considerable administrative support is required from both the central offices of INIAP and the regional experiment stations for the on-farm researchers to carry out their work effectively. Considerable attention has been paid to the delineation of responsibilities among the various research programs and departments and the PIP. The feedback mechanism between the PIP and the crop programs and research departments of the experiment stations has been considered as a fundamental dimension in the institutionalization process. The PIP has been given the primary responsibility of identifying farmer requirements for new technology and the experiment stations have been given the responsibility of generating new technological components in response to those requirements.

Table 3. INIAP's production research programs, 1977-80

Name and Location	Crops	Administrative Exp. Station	Technical Exp. Station (s)	Year Establised
Imbarura	Maize, Beans	Sta. Catalina	Sta. Catalina	1977
Cayambe (Pichincha)	Wheat	Sta. Catalina	Sta. Catalina	1977
Samborandon (Guayas)	Rice	Boliche	Boliche	1978
Loja	Maize, Cassava, Peanuts	Boliche	Pichilingue, Boliche	1978
Balzar	Maize, Cassava	Pichilingue	Pichilingue	1978
Carchi	Potatoes	Sta. Catalina	Sta. Catalina	1979
Quimiag-Penipe (Chimborazo)	Maize, Beans	Sta. Catalina	Sta. Catalina	1979
Manabí	Maize, Castor Bean, Pumpkin	Portoviejo	Portoviejo	1979
Puerto Ila-chone (Manabí)	Coffee, Cocoa, Maize	Portoviejo	Pichilingue Portoviejo	1980
Quinindé (Esmeraldas)	Coffee, Cocoa,	Sto. Domingo	Pichilingue	1980

The established research programs and departments concentrate most of their research work on INIAPs experiment stations. These researchers also continue to carry on regional trials under varying ecological conditions to detrmine the yield potential of the technological components developed on experiment stations. The PIP has a more explicit responsibility for the actual formulation of production recommendations for defined recommendation domains.

The complementary nature of the PIP to the experiment station research programs and departments has been strongly emphasized. Through a production research program, a substantial number of professionals achieve a better understanding of the problems and needs of farmers, and become more effective in generating and disseminating alternative technologies for the improvement of the welfare of rural families. In order to strengthen communication and coordination between the PIP and INIAP's experiment station programs and departments, the plans of various PIP trials in each region have been reviewed by the technical committees of the experiment stations which support a particular PIP project. These technical committees, in existence for a number of years, meet once a week to consider and approve specific research proposals prepared by INIAP's various programs and departments. Annual research plans of work for the PIPs also are reviewed and approved by these committees. A system of quarterly reporting by the PIP field staff has also been formalized so that feedback information from the on-farm trials is regularly sent to the experiment station.

The PIP is also seeking to strengthen the respect and trust between researchers and extension agents. Through the PIP, a more integrated and stable working relationship, based upon collaborative field work, has emerged between research and extension. Extension and researchers cooperate in production surveys, selection of on-farm cooperators and trial sites, evaluation of the research data, and dissemination activities associated with recommended technologies. Additional efforts to strengthen and consolidate the relationship of research and extension are also being made through the establishment of common training and technology evaluation activities.

Training

From the first cycle of on-farm experimentation in the Province of Imbabura in 1977, it was noted that the station-based INIAP scientists tended to favor experiments with many variables and levels for each component in the study, following traditional station research methodologies. It was also evident that few of INIAP's researchers were trained to identify non-biological factors influencing the

small farmer. For these reasons, training in on-farm research procedures has been a central activity since the inception of this research program.

Through 1982, two types of training have been offered to INIAP's production researchers. Each year a few INIAP scientists have attended CIMMYT's in-service production agronomy training courses in Mexico. In addition, a strong and on-going national in-service training program was developed to provide the growing number of production researchers with the necessary skills to undertake programs of on-farm research. This training goes on each year and features a unique system of bringing together participants for short periods during critical stages of the research process.

The key skills taught in the current version of the training program are:

1. Training in the identification (through a sequence of surveys) of the biological and economic circumstances affecting the small farmer.

2. Training in basic production systems, with the trainees carrying out all phases of the cultivation practices.

3. Training in basic agricultural research methodology, principally in experimental design and on-farm execution for verification of technology.

4. Training in methods for economic analysis of experimental data to formulate production recommendations.

INIAP plans to continue to utilize different individual PIP research projects each year as in-service training sites for newly hired on-farm researchers, as well as for extension agents engaged in technology transfer activities. With the system of training used, on-going production research and training can be combined into an effective system for production workers to gain practical experience in the PIP research methods.

In 1981, USAID committed funds to Ecuador to help INIAP consolidate and support the PIP during 1982-85. Five of the ten PIP project areas are funded under this agreement. Included in the grant are funds for sending PIP researchers for graduate training at the M.S. degree level.

CONCLUDING COMMENTS

The process of institutionalization of the PIP is still under way. A variety of coordination problems are still unsolved. The PIP staff are responsible in technical and administrative matters to heads of the various INIAP experiment stations. As well, their activities are coordinated by the national PIP coodinator based in the central INIAP offices in Quito. The current national PIP coordinator is also head of the Agricultural Economics Department. Because of his dual responsibilities as well as budget constraints, the PIP coordinator is not able to visit each of the PIP field programs more than three times a year.

Although the PIP researchers are administratively attached to an INIAP experiment station, their work is carried out away from the station and they operate with a considerable degree of independence in scheduling activities, a situation which has been criticized by some experiment station heads who feel that inadequate supervision is being exercised over PIP personnel. Closer supervision, however, is occuring in those PIP field programs that are integrated into the national integrated rural development projects. In these cases, the PIP field staff are administratively responsible to the project leader of each integrated rural development project.

Another problem has been related to the PIP budgeting situation. Much of the financing of the PIP up to 1982 has been through special grants from international donor agencies, and many of the PIP personnel are still not permanent INIAP staff members. Some vehicles and supplies have been provided through these special grants. For most logistical support (materials for experiments, spare parts for vehicles reimbursements for gasoline, payment of salary) the PIP field staff rely on their respective experiment stations, where their requests are handled by the station director. The PIP national coordinator, in addition to his technical support responsibilities to the PIP field staff, has had to devote a considerable portion of his time in order to expedite administrative matters, particularly related to payment of official expenses, rents, input purchases, and vechicle repair associated with the field research programs.

The PIP research staff tends to be young with most in the beginning INIAP professional salary grades. Although they receive the same basic pay as other INIAP staff of the same grade, their rents are paid because they live in the field. In addition, they receive a cost of living allowance. This allowance was granted because the work of the PIP field staff involved more risks than station work; PIP technicians spend long hours on roads and paths that are in poor condition, often work in isolated areas, and generally have

more irregular hours of work. Further the PIP field staff generally cannot easily avail themselves of station facilities and fringe benefits such as libraries, clinics, and subsidized food that are readily available to the regular station-based INIAP staff. Finally, PIP field staff, because of the nature of their work, do not have the option of supplementing their income through teaching as do some experiment station researchers. Nevertheless, the PIP allowances have been questioned by other INIAP staff.

The final point of contention is that of the role of the PIP vis-a-vis experiment station research programs and departments in the generation of technology. The question basically centers around who should be responsible for the final shaping of INIAP's production recommendations to farmers--the PIP or the various crop improvement programs and research departments. Some view the PIP as the final step in the research process which leads to the development of recommendations. Others see the PIP solely as an off-station testing service unit for experiment station research programs and departments. It should, however, be clearly understood that the PIP is not a disciplinary research activity of either biological or social scientists, but rather a collaborative, multidisciplinary research approach in search of alternative technologies that are valid for Ecuadorian farmers.

After five years of experience, there is an emerging concensus among INIAP scientists about the potential contribution of the PIPs to national production-oriented research. In the course of a few years, the work in Imbabura has given evidence of the need for improvement in existing recommendations and has pointed out the need for earlier-season varieties, careful tailoring of fertilizer recommendations to the agro-climatic circumstances of defined areas, more effective insect control, improvements in pea and broad bean varieties, effective weed control technology, and research on water management. Equally useful results are emerging from the work of other PIPs, e.g., work on wheat technologies has pointed the way to substantially different fertilizer recommendations and has opened new issues for the relationship between soil tests and fertilizer applications.

It was this flow of results and opportunities that led INIAP leadership to develop the PIP program and to expand its scope. Clearly, the contribution of the PIPs, through on-farm research, points to a growing partnership for the program within INIAP in the forging of more appropriate production technologies for Ecuadorian farmers.

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