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9. ABSTRACT
This design study examines the impact of the different training strategies of the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT) on helping LDCs to build a national research capacity. In CIMMYT's case, it was expected that once a "critical mass" of trained research workers was present in a wheat improvement program, that program would function effectively and that it would 1) work out its own research structure to fit local needs and requirements and 2) take over the necessary informal on-the-job training of new personnel. To achieve this, CIMMYT concentrated on one specific production problem, the need for improved genetic technology and through its training strategy, built carefully and systematically this relatively simple research function into each national program. Thus organizational change was a specific, but implicit, training objective and it appears that this strategy is working. IRRI uses the research project approach and trains research workers in separate disciplines. While trainees study production problems relevant to home country conditions, it appears that in most cases their research effort -- as it contributes to the overall national research capacity -- lacks sufficient emphasis on and attention to the problem of producing biological technology.

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Institution Building: Impact of the International System on National Research Capacity– The IRRI and CIMMYT Training Programs

This paper was written as part of a research project on international technology transfer systems being supported by the Program of Advanced Studies in Institution Building and Technical Assistance Methodology (PASITAM) of the Midwest Universities Consortium for International Activities (MUCIA) through a 211 (d) grant from the U.S. Agency for International Development. The original research, on which this paper is based, was supported by grants from the International Rice Research Institute, the International Maize and Wheat Improvement Center and the Land Tenure Center, University of Wisconsin.

The development and international transfer of improved agricultural technology (particularly the high yielding varieties of rice and wheat) made a dramatic impact on agricultural production in many parts of the tropics and subtropics during the late sixties and early seventies. These production successes were largely spearheaded by the research work carried out at two international research and training centers: the International Rice Research Institute (IRRI) in the Philippines and the International Maize and Wheat Improvement Center (CIMMYT) in Mexico. Donor nations are now looking increasingly to international research centers as an effective means of helping less-developed nations solve many of their critical technological problems in agriculture. However, as these poor nations shift to agricultural production systems based on modern science and technology, it is imperative that they build their own effective research institutions to meet long-term technological needs. This Design Study examines the impact of the different training strategies being employed by IRRI and CIMMYT in helping to build this national research capacity.

Transferring Research Capacity

It is necessary first to clarify how research capacity is being viewed in this paper. Ruttan and Hayami considered the problem of international technology transfer and differentiated the process into three phases: (1) material transfer, (2) design transfer, and (3) capacity transfer.[1]

The international transfer of wheat and rice technology during the late sixties was largely in the "material transfer" stage, as represented by the substantial international seed importations carried out by many less-developed countries (LDCs) during that period.[2] At the same time, "design transfer" was occurring as national research institutions began to receive new, high yielding experimental lines and varieties of wheat and rice that were, in turn, tested and in some cases multiplied and released to agricultural producers.[3] In addition, the third phase of the technology transfer process, or "capacity transfer," was receiving attention by these international research centers through their training and outreach programs. However, building a national research infrastructure (i.e., capacity transfer) that can produce scientific knowledge and improved agricultural technology—and adapt it to local ecological, resource, and institutional

conditions—has been found to be a slow, difficult, and complex task.[4]

To better understand the institution-building task associated with capacity transfer, it is useful to differentiate research capacity into its two primary functional components: science and technology. During a parallel discussion on technology transfer in space science, Price developed some generalized definitions that are useful to this discussion: science is taken to be those research activities that result in scientific papers being written and published, and technology is ". . . that research where the main product is not a paper, but instead a machine, a drug, a product, or a process of some sort."[5]

The point in making these rather sharp distinctions between science and technology is not to artificially separate one part of this functional process from the other or to suggest that research workers should work in only one area or the other. Many agricultural research workers function in both knowledge generating (science) and technology developing roles and move easily and effectively between them. But in organizing national research institutions, there has been a tendency to overlook the technology development function.[6] Therefore, it is important to know which hat a research worker has on at any one time so we can better understand the thrust of his overall research program and how it contributes to national research capacity.

Both scientists and biological architects who develop improved agricultural technology use many common research tools, but differences in research objectives and output demand substantially different types of cognitive behavior.[7] In his pursuit of new knowledge, the scientist largely engages in analytical research. Analysis, as a cognitive skill, ". . . emphasizes the breakdown of the material into its constituent parts and detection of the relationships of the parts and of the way they are organized."[8] The scientist, in turn, uses different research tools as a means of verifying specific hypotheses that result from his analytical inquiry.

The biological architect largely engages in creative thinking, and by trying new materials and methods in different combinations and amounts, attempts to develop new technology or technological components that will better achieve a production objective (such as increased output, reduced risk, or reduced costs). In terms of cognitive behavior, this creative thinking is characterized as synthesis.[9] In synthesis, the research worker ". . . must draw upon elements from many sources and put these together into a structure or pattern not clearly there before. His efforts should yield a product."[10] The biological architect, in turn, uses research tools to test or evaluate these new technological combinations or components that he has created to determine their production potential.[11] Perhaps it is because the biological architect must spend so much of his time evaluating his new technological combinations and components—through the

use of relatively simple and routine research trials and tests—that the importance of his intellectual or cognitive contribution has been overlooked or minimized.

This framework has been applied to research capacity as it relates to crop technology. In the past it was the plant breeder who generally developed improved genetic technology by manipulating different genetic factors to produce improved varieties, and the production agronomist who developed and refined improved production recommendations for farmers' use by manipulating new and/or existing factors of production (such as improved varieties, fertilizers, pesticides, cultural practices, etc.) in new or different ways. In more recent years, as agricultural technology has become increasingly sophisticated and complex, the trend has been to form interdisciplinary research teams who work together in manipulating and integrating different chemical, biological, or mechanical factors of production in building superior agricultural technology.[12]

Before moving into a discussion of the training strategies being used by IRRI and CIMMYT, and the impact these strategies have on research worker behavior and research capacity, one other institutional factor should be noted that appears important to the question of science and technology and the process of building national research capacity. This factor is the predominant reward system within agricultural research that appears to be having an important and continuing influence on research worker behavior and national research capacity.

Reward Systems In Agricultural Research

One explanation as to why research institutions in many LDCs have been ineffective in producing improved agricultural technology is that research workers have tended to concentrate on more theoretical research problems rather than working to solve farmer production problems.[13] An hypothesis that is logically consistent with and will explain this behavior is that agriculture research workers in LDCs have adopted or internalized the normative structure of the public research establishment (the university and the corresponding academic/scientific professions) of industrially developed countries.[14] The following factors serve to support and elaborate on this hypothesis.

First, most research workers in the LDCs with advanced degrees received their academic training in foreign universities, primarily in the United States and Europe. Many of these research workers may have been influenced (socialized) by the "publish or perish" reward system that is common to large, research-oriented colleges of agriculture in the United States. Furthermore, advanced research degrees generally require an "original" research inquiry that contributes to the body of knowledge in the respective discipline; therefore, these research projects are frequently

highly specialized and theoretical in nature. Both of these factors could tend to orient young research workers toward more theoretical, scientific inquiries.

Second, in the United States the knowledge generating research function (science) is primarily carried on within the public sector (universities), whereas the majority of technology developing research is carried out in the private sector (industry).[15] Although research workers who conduct technology development types of research have much less opportunity to publish in scientific journals and to gain professional recognition from their colleagues, salary schedules in private industry have traditionally been higher than in public research institutions. Thus, in the overall agricultural research system of the United States, there is, to some extent, a trade-off between professional and economic rewards. Research workers, depending on their interests, abilities, and what they consider to be important, have alternative career patterns they can pursue.

On the other hand, in LDCs, most (if not all) of the national agricultural research capability is located within the public sector, generally within a ministry of agriculture or a university. Therefore, the opportunity for research workers to select between economic and professional rewards is quite limited. Agricultural research workers receive salaries according to the bureaucratic procedures and criteria being followed by the research institution, not according to the type of research carried on. Therefore, there is no potential within the research institution itself for inducing research workers (through economic rewards) to pursue career patterns oriented toward technology development research objectives.

Thus, in the absence of an alternative reward system, it appears inevitable that professional rewards will take on increasing importance in influencing the types of research activities being undertaken by research workers in LDCs—particularly given the professional recognition associated with publishing in a prestigious scientific journal with an international clientele.

Third, in most cultures agricultural work is considered a low-status occupation; therefore, there are no positive social rewards (essentially only negative ones) that would encourage a highly trained research worker to work on practical problems—the results of which would only be of direct importance to a peasant or cultivator and which would not result in any significant professional recognition. Even if individual scientists were motivated to do this type of research, the research organization has no effective way to formally reward these successes.

Finally, the spirit of cooperation is frequently missing from national research institutions, and scientists may tend to think in terms of achieving *personal* rather than *institutional* credit. To develop improved

agricultural technology requires considerable interdisciplinary cooperation, but in this case the credit accrues to the team, not to the individual. If this team credit is usurped by the research director or the team leader rather than being shared by the team members, individual research workers will not be encouraged to work together on future endeavors.

Given all these factors, it is apparent why many agricultural research workers in LDCs prefer to concentrate on individual research projects aimed at generating new knowledge where they can directly receive professional recognition and rewards. In most national research systems in LDCs, there are too few positive rewards and incentives to encourage research workers to carry out technology development types of research. It is no wonder, as Singer suggests, that the meager research resources of the LDCs (estimated at 2 percent of the world's research and development expenditure) are frequently misdirected to research problems that are more relevant and useful to the rich nations.[16]

The next section will briefly describe the training strategies being employed by IRRI and CIMMYT in helping Third World nations achieve capacity transfer.[17]

The CIMMYT Wheat Training Program

The wheat training program in Mexico is an integral part of CIMMYT's overall outreach program to make improved wheat technology available to farmers in all major wheat growing regions of the Third World.[18] Strong national programs are an essential part of this international wheat improvement strategy, both in the process of developing and disseminating improved wheat technology, and also in dealing with the technological spin-off problems (primarily disease epidemics) that are a potential threat to the precarious food balance in population dense nations.

When the wheat revolution began to spread beyond Mexico in the early sixties—particularly to South Asia and the Middle East—national wheat improvement programs in these areas were generally weak and poorly organized. CIMMYT used training programs to upgrade the technical skills of research personnel in an attempt to build strong, *independently functioning* national programs that are *interdependent* with other national programs and with CIMMYT for new genetic resources and technical information.

At all levels, CIMMYT stresses a "team" or integrated approach to wheat improvement. At the program level, the emphasis is on interdisciplinary teams that are well integrated in function. At the international level, the national programs and CIMMYT work together as part of an overall international wheat team to systematically share superior germ plasm and new varieties as soon as they are developed, as well as technical information on these genetic materials.

The major thrust of the wheat training program is directed toward middle-level research workers. The program revolves around three main educational objectives: (1) to impart to trainees the research skills and knowledge needed to run a wheat improvement program, (2) to encourage and develop the trainee's ability to create (synthesize) new forms of wheat technology, and (3) to foster specific types of attitudinal change among trainees.

Technical Research Skills

The first half of the regular eight- to nine-month training program in wheat improvement deals primarily with the mechanics of running an efficient, well-organized research program. Trainees learn all the essential research skills and techniques needed to manipulate and evaluate new forms of wheat technology. This training is accomplished through "on-the-job training."[19] Trainees follow the CIMMYT wheat program through each stage of the growing season (and the varietal development process) with each task or operation first being discussed in the classroom and demonstrated in the field. After the trainee has the opportunity to practice the skill and is "checked out" to insure that he is reasonably proficient, he proceeds to help carry out each research task or operation within the ongoing CIMMYT research program.

Technical Research Ability: Synthesis

Once the trainee learns the "nuts and bolts" of operating a research program, he can give increasing emphasis to the content or the materials passing through the research program. For example, the job of the breeding team is to create (synthesize) new genetic lines and varieties by combining and recombining diverse types of germ plasm. To be effective and efficient in developing improved high yielding varieties, the trainee must learn and become increasingly familiar with the various genetic characteristics and materials he is attempting to manipulate. For example, an experienced biological architect in the CIMMYT wheat program can walk up to an advanced generation plot—there are hundreds of such plots—and from visual inspection alone give the approximate pedigree of the line (from several hundred potential parent lines and varieties), give several reasons why the cross was made, and evaluate the line for those visual characteristics. By working side-by-side with experienced biological architects in the CIMMYT wheat program—and by asking and being asked the question: "why?"—trainees soon begin to develop an ability and an insight into the creative process of genetic engineering.

Attitudinal Objectives[20]

There is a common expression used in the CIMMYT wheat training programs: "The plants are talking to you, but you have to use your *eyes*

to hear what they are saying." In other words, wheat plants being grown under a variety of different conditions (favorable and hostile environments) respond differently to those conditions. A good observer is able to detect how plants react to each of these different environmental conditions and, using these data, to select those genetic lines with the greatest potential.

CIMMYT seems to use a similar selection technique for its trainees. For example, CIMMYT has been criticized by some visitors to the training programs in Mexico for "using" trainees for such routine tasks as inoculating segregating populations with rust spores. This is a job that CIMMYT needs to have done; it requires about ten days to two weeks of hard, back-breaking work, wading through muddy plots (many times in the rain), and injecting two tillers of each plant with a syringe full of disease inoculum.

After the first morning of this activity, there is no additional technical training value to be accomplished; however, what the CIMMYT staff learns about the "trainee population" during these two weeks is very important. Some trainees can disguise their displeasure for this type of work for a morning or two; but after a week or ten days, trainees are clearly segregating in their "reaction to hard field work." Some trainees may do the work while CIMMYT staff members are nearby, but then relax under a tree when they leave (representing an attitude of "compliance," given this type of behavior). Still others may call in sick for a few days to avoid the work (noncompliance), while others are out in the plots getting the work done. CIMMYT particularly wants to identify this last group of trainees who either "identify with," or have "internalized" positive attitudes toward this type of research.[21] CIMMYT believes it is this last group that will begin to make up the hard core of working scientists within the national wheat improvement program.

The training program in Mexico is viewed by the CIMMYT wheat team as only the first step in a long-term process of building effective wheat research workers and national wheat improvement teams. Because of this long-run perspective, the training program becomes both a manpower development tool for training skilled research technicians and an "early generation" selection tool for identifying potential "biological architects." Trainees are observed in Mexico and again back home on the job. Those who excel in attitude, outlook, intellectual ability, and technical know-how—in both working environments—are identified as prime candidates for academic fellowships. By giving these individuals additional educational opportunities, it is hoped they will become key biological architects in their own national wheat improvement programs in years to come.

Results[22]

This training strategy results in approximately 82 percent of former trainees still actively engaged in wheat research and production activities, with another 8 percent being indirectly or partially involved in wheat improvement work. Only about 10 percent of former CIMMYT Wheat trainees are no longer working in wheat improvement programs.

As shown in Table 1, the work performance of those former participants still actively engaged in wheat research and production programs (105 trainees of 130 total respondents) is high, as measured by the number of research experiments, replicated field trials, genetic crosses, and production plots completed. Furthermore, it emphasizes technology development as opposed to experimental research—particularly in the area of genetic technology.[23] It appears that the work behavior of CIMMYT trainees, once back home on the job, is quite consistent with CIMMYT's training objectives.

CIMMYT appears to be very effective in producing research workers who can develop improved genetic technology, but this success has not yet been realized in producing the other half of the wheat improvement team which can develop the complementary package of practices. This

TABLE 1 AVERAGE NUMBER OF RESEARCH AND PRODUCTION ACTIVITIES COMPLETED BY CIMMYT WHEAT TRAINEES ACTIVE IN WHEAT IMPROVEMENT PROGRAMS, 1972

Type of Activity	Number & Percent of Trainees Conducting Each Activity (N = 105) N	%	Mean Level per Trainee (N = 105)
A. Laboratory or Greenhouse Experiments	13	12.4%	1.37
B. On-Station Field Experiments	56	53.3%	5.62
C. Genetic Crosses	56	53.3%	227.10
D. On-Station Replicated Applied Research Trials	65	61.9%	7.24
E. On-Farm Replicated Applied Research Trials	44	41.9%	4.74
F. On-Farm High Yielding Production Plots	37	35.2%	3.71

weakness probably stems from the fact that the CIMMYT research program concentrates on widely adapted genetic technology, with production technology being viewed as a location-specific problem. The fact remains that wheat production agronomists are sorely needed in most national programs to develop appropriate production recommendations that will enable farmers to fully and economically exploit the production potential of the superior varieties that are being developed.

The IRRI Training Programs

The training programs at IRRI in the Philippines are an important part of the institute's international activities. The research and rice production training programs make up the major thrust of the IRRI's training activities. Their impact on national research capacity is described and analyzed here.

IRRI Research Training Program

The IRRI research training program is an integral part of the institute's ongoing research activities and its international cooperative programs. The institute is committed to strengthening national rice research programs, and IRRI's leaders see the research training program as a resource that national programs can use in upgrading the technical proficiency of their staff members.

IRRI's research training approach centers around the research project. Trainees are expected to focus on a serious production problem in their home country and to carry out one or more research projects that will generate new knowledge and possible solutions.

Research trainees work closely with a senior IRRI scientist and frequently carry out research projects that are an integral part of the advisor's overall research. In some cases, these research efforts result in jointly authored research papers that report important research findings and contribute to the growing body of knowledge about rice production in the tropics.

Although some advanced research trainees come to IRRI to learn specific research skills and techniques, or to conduct research projects that are beyond the scope of their national program (because of the lack of adequate scientific equipment), the major objective of the project approach is to provide participants with a solid research experience—teaching them each step involved in planning, designing, executing, and reporting on a research project. At each step of the way, trainees learn by doing. In terms of educational objectives, the major focus of the project approach is on *analysis,* using research as a tool to generate new knowledge about production problems and their possible solutions, and/or to test suspected relationships between production factors. The knowledge

generated from these projects may be used in the development of improved rice technology that will increase rice production in the tropics.

There are two exceptions to the project training approach. (1) Nondegree trainees in varietal improvement do not conduct research projects but work largely as research assistants in IRRI's ongoing rice breeding program. Again these trainees learn by actually carrying out each task involved in a varietal improvement program and, at the same time, become familiar with the germ plasm currently being used in the IRRI program. (2) Agricultural engineering technicicans are given short-term training so they can evaluate and demonstrate IRRI-developed machinery in their own countries under local conditions.

Research trainees work in a disciplinary department at IRRI, but the Saturday Seminar has become the institutional mechanism by which both trainees and staff learn recent research findings in other departments. By sharing research results with staff members in other disciplines, scientists can frequently gain new insights and perspectives on important rice production problems which may lead to cooperative efforts between departments. When these multidisciplinary team efforts occur, they demonstrate to trainees how an effective research institute can organize its scientific resources in different ways to solve production problems.

The institute is conveniently located next to the University of the Philippines College of Agriculture, and about one-third of IRRI's research trainees combine an M.S. degree program at the college with research training at the institute. IRRI scientists believe that combining a degree program with a solid research experience enables trainees to perform more effectively after returning home; it also gives them the necessary educational credentials to move into leadership positions in their respective national programs. In general, IRRI research trainees are a highly educated group. At the time the participant follow-up survey was taken in 1973, 41 percent of the research trainees had M.S. degrees, 43 percent had either received or were working toward Ph.D. degrees, while only 16 percent of the group were still at the B.S. degree level.

Results

Former IRRI research trainees reacted in very positive terms when assessing their training experience at the institute. IRRI selected both research and teaching personnel from national institutions, and more than 90 percent of all research trainees indicated that the training had been of use to them since returning home. In addition, approximately 71 percent of former trainees (who were working when the survey was taken) were still actively involved in rice research or production programs.

In considering the main educational objective associated with the proj-

ect training approach (i.e., analysis), it seemed consistent to expect trainees to continue working in experimental (analytical) research after returning home. To verify this hypothesis, the work behavior of former trainees was examined to determine which types of research were being emphasized (see Table 2). As expected, more knowledge-generating types of research (field, laboratory, and greenhouse experiments) were being carried out than research activities associated with the direct development of rice technology (agronomic field trials and genetic crosses).[24]

Another factor considered in determining the type of research being emphasized by IRRI research trainees was the form of research output, particularly since research papers are the primary output from knowledge-generating types of research. First, it was found that 106 research trainees had been able to publish (or present) a total of 187 research papers based on the research work they completed while at IRRI. Second, trainees were asked if they had been able to publish or present any research papers based on research conducted since returning home. In the two-year period (1971-72), 130 former research trainees produced 370 techincal papers. Since only 154 trainees indicated they were actively

TABLE 2 AVERAGE NUMBER OF RESEARCH AND PRODUCTION ACTIVITIES COMPLETED BY IRRI RESEARCH TRAINEES ACTIVE IN RICE RESEARCH AND PRODUCTION PROGRAMS, 1972

Type of Activity	Number & Percent of Trainees Conducting Each Activity (N = 154) N	%	Mean Level per Trainee (N = 154)
A. Laboratory or Greenhouse Experiments	65	42.2%	1.61
B. On-Station Field Experiments	85	55.2%	3.48
C. Genetic Crosses	46	29.9%	19.90
D. On-Station Replicated Applied Research Trials	57	37.0%	1.55
E. On-Farm Replicated Applied Research Trials	38	24.7%	1.17
F. On-Farm High Yielding Production Plots	39	25.3%	1.46

engaged in rice research and production programs when the survey was taken, and only another five percent of former trainees were working in other crop research programs, it was concluded that knowledge-generating types of experimental research are heavily dominating the work behavior of former IRRI research trainees.[25]

IRRI Rice Production Training Program

The IRRI rice production training program was established in 1964 in response to a growing need for competent rice extension specialists who could: (1) diagnose serious rice problems; (2) grow a rice crop using the high yielding rice technology being developed by IRRI; and (3) communicate these skills, methods, and techniques to rice producers through efficient extension methods.[26] Later, as it became apparent that IRRI could not begin to train all the rice production specialists needed by national programs, its focus was shifted to "training the trainers" of rice production specialists. The logic of this approach was to create a multiplier effect within each national program whereby large numbers of field extension workers could be trained to use and demonstrate the new improved rice technology.

The rice production training program is a six-month course conducted during the wet rice growing season beginning in early June each year. The behavioral objectives of the present program, in addition to the three original objectives mentioned above, are: (1) for trainees to be able to conduct applied research trials to modify the modern rice technology (package of practices) to fit local growing conditions in their home countries and/or regions; and (2) to be able to organize and teach in-service rice production training programs for extension personnel in their home country programs.

To achieve these behavioral objectives, trainees spend about half of their time in the classroom gaining up-to-date knowledge about modern rice production in the tropics, and the other half in the field practicing this knowledge, acquiring new skills in rice production, and communicating this technical information. One of the most outstanding features of the training methodology is that the classroom instruction, which imparts extensive technical information about all aspects of modern rice production, is carefully organized around and integrated with the practical field training. What is learned in the classroom is directly relevant to the problems faced in the field. Second, the course is highly efficient in that it is completely organized before the trainees arrive (lectures, field practice, field trips, etc. are all scheduled), so that each hour is accounted for in terms of the instructor responsible and the behavioral objectives to be achieved. In addition, most technical lectures, field practice, exercises, etc. are reproduced and made available to trainees so each has a rice

production training manual and a complete set of technical lecture notes to use both during the training program and after returning home.

Results

Questionnaire responses show that nearly every former rice production trainee was satisfied with the overall training, and approximately 90 percent of the trainees indicated they were making some or full use of the training. The number of respondents who indicated they were in job assignments where they could make direct use of their training was less satisfactory. Although 81 percent of the respondents indicated that they were working in rice production programs, only about 42 percent were in positions directly associated with the stated behavioral objectives of the program.

In regard to the primary behavioral objective of the program, it was found that only nineteen respondents (12.8 percent) were working as full-time rice production trainers. Although two-thirds of the respondents indicated that they had worked, at one time or another, in organized rice production training programs, in most cases these duties were in addition to their regular job assignments. In addition to the nineteen respondents, it was found that another thirty-six respondents (24.3 percent) were working as rice extension specialists, and eight trainees (5.4 percent) were involved with rice production programs as general agricultural extension workers. In all of these cases, trainees were considered to be directly involved in assignments associated with the behavioral objectives of the program.

Approximately one-fourth of the rice production trainees are research workers in their home countries. In fact, nearly 10 percent of former rice production trainees are currently working in rice breeding. How or why these trainees were selected for this program, rather than the research training program in varietal improvement, was not established. Although rice production training is probably quite useful and appropriate for many rice research workers, their selection appears inconsistent with the stated objectives of the rice production training program.

The remaining trainees have moved into other types of job assignments since returning home (many in administrative positions); but some are still associated with rice production work. Eleven participants were attending a university when the survey was taken, and probably many of these will eventually return to rice production activities.

Effect of Different Training Strategies on Work Behavior

It was established in this study that the work behavior of trainees in each of the three groups differed widely following their return to national job assignments. At the same time, however, there were great

similarities in the general background characteristics of the trainees. Therefore, the purpose of this section is to develop an adequate explanation for these differences in work behavior by examining the major independent and intervening variables.

No attempt is made to characterize one training program as being better or worse than another; rather, the objective is to learn from the strengths and weaknesses of each training strategy. All training programs included in this study are generally well organized and well received by former trainees. To establish this point, two major trainee assessment variables are contrasted in Table 3.

TABLE 3 GENERAL TRAINEE ASSESSMENT OF EACH TRAINING PROGRAM

Type of Training Assessment	CIMMYT Wheat Trainees	IRRI Research Trainees	IRRI Rice Production Trainees
Trainee's overall satisfaction with the training program:			
very satisfied	65.4%	55.6%	64.0%
somewhat satisfied	32.3%	35.5%	34.7%
neutral or dissatisfied	2.3%	8.9%	1.3%
total	100.0%	100.0%	100.0%
Trainee's use of training in his present job assignment:			
full use of training	46.4%	39.4%	48.6%
some use of training	47.2%	55.5%	42.1%
little or no use of training	6.4%	5.1%	9.3%
total	100.0%	100.0%	100.0%

There is little or no difference as to how individual trainees have perceived the use of their training, as well as how they have assessed their training experience at each center. Therefore, from the viewpoint of the individual trainee, each training program has been effective in achieving its specified training objectives.

As mentioned, however, trainees are performing differently in their present job assignments. Data on individual trainee work behavior are presented in Figures 1 and 2 for the three training groups, based on the subgroups of trainees who actually indicated direct involvement (when the survey was taken) in a wheat improvement or rice research and production programs. The percentage of trainees indicating such direct involvement for each training group is as follows: CIMMYT wheat trainees,

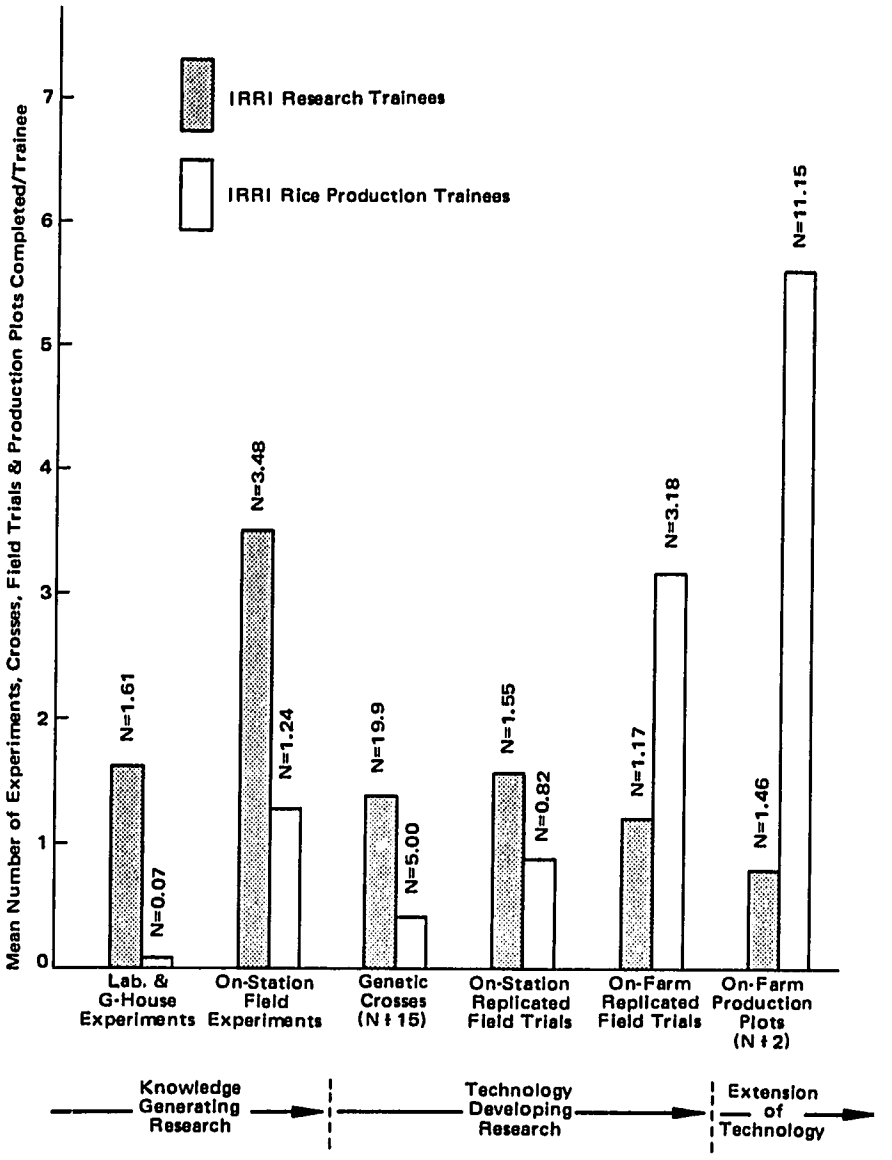


FIGURE 2 WORK BEHAVIORAL PATTERNS OF FORMER IRRI RESEARCH AND PRODUCTION TRAINEES

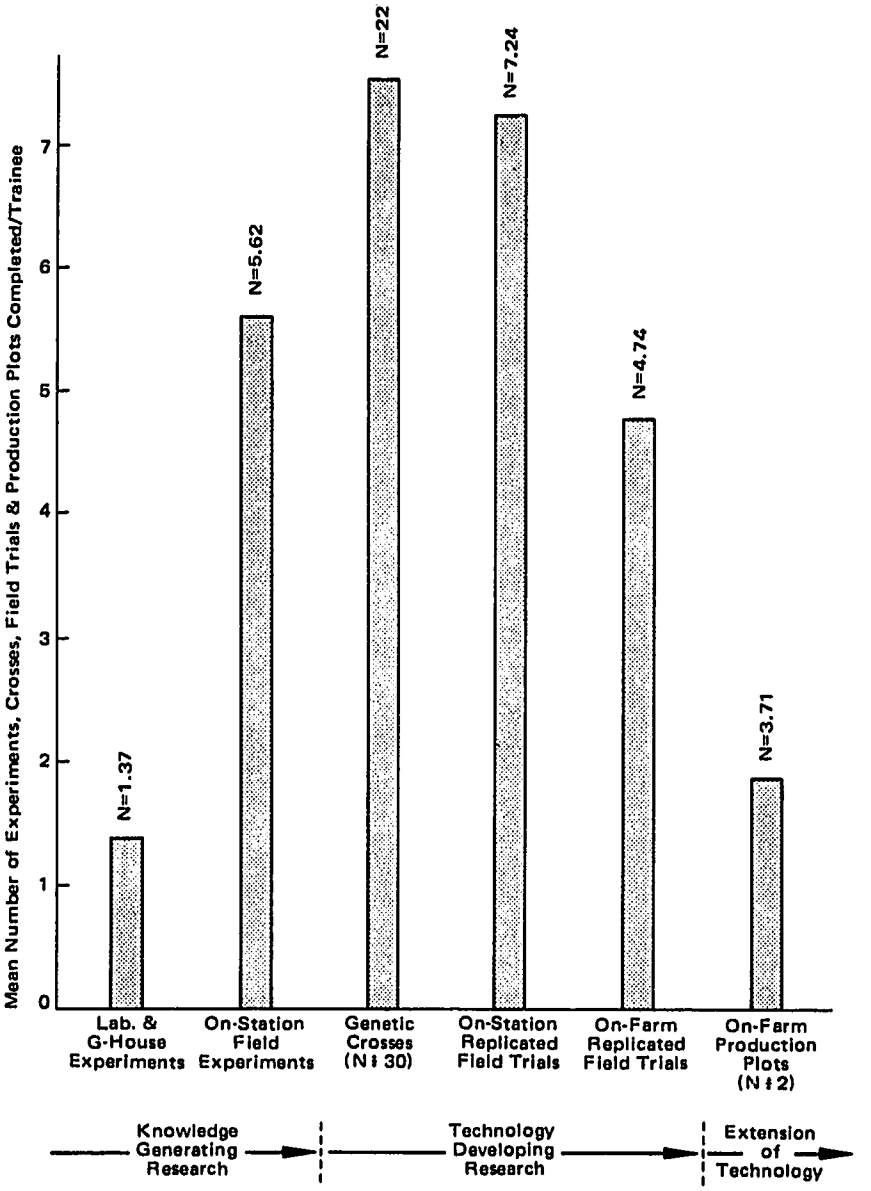
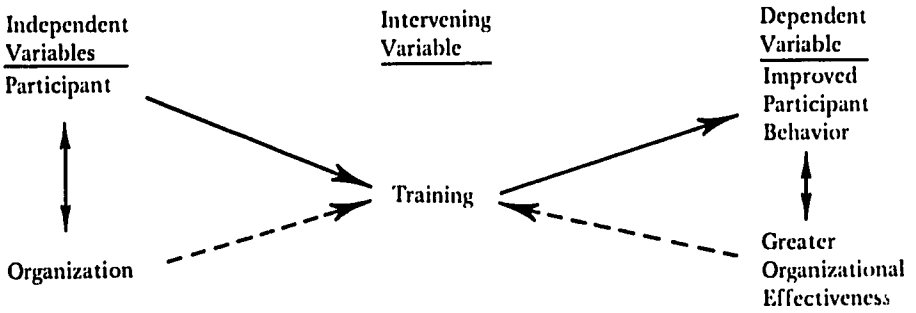


FIGURE 3 WORK BEHAVIORAL PATTERNS OF FORMER CIMMYT WHEAT TRAINEES

83.3 percent (N = 105); IRRI research trainees, 71.3 percent (N = 154); and IRRI rice production trainees, 78.8 percent (N = 108). See Tables 1 and 2 for additional data.

It is clear from the data presented that CIMMYT wheat trainees are completing more research activities associated with the development of biological technology than are IRRI research trainees.[27] While this difference in research emphasis was expected, the extent (i.e., level) of these observed differences was not anticipated. Since these differences have an important influence on the type of national research capacity that develops, a detailed esamination of the factors that contributed to these differences was warranted.

To account for these differences, an analysis was made using a conceptual model of the training process developed by Lynton and Pareek (see Fig. 3).



Source: Lynton, R.P. and Pareek, Udai, *Training for Development*, Richard D. Irwin, Inc., and the Dorsey Press, 1967, p.18.

FIGURE 4 A MODEL DEPICTING THE ROLE OF TRAINING IN BEHAVIORAL AND ORGANIZATIONAL CHANGE[28]

First, an examination was made of the two major independent variables: (1) personal characteristics of individual trainees, and (2) characteristics of trainees in their work organizations for each training group. Then, differences in the main intervening variable—the actual training strategy and approach employed by each institute—were considered.

Personal Characteristics of Trainees

Several key variables describing the personal background and characterictics of trainees were tabulated to determine if there were any significant differences in the types of trainees being selected for each program.[29] Table 4 summarizes data on those characteristics that might be expected to influence work behavior.

In terms of background characteristics, there are two apparent differences between the two research training groups which could affect work performance. First, as documented in Table 4 is the difference in educa-

TABLE 4 PERSONAL CHARACTERISTICS OF TRAINEES IN EACH TRAINEE GROUP

Personal Characteristics of Trainees	CIMMYT Wheat Trainees (N = 130)	IRRI Research Trainees (N = 234)	IRRI Rice Production Trainees (N = 148)
A. Mean age when entering the training program (in years)	30.6	30.4	32.4
B. Percentage of trainees who grew up in rural areas	61.4%	59.5%	77.0%
C. Percentage of trainee fathers who were engaged in agricultural jobs	47.5%	36.7%	45.8%
D. Percentage of trainee families whose main source of income was from agricultural sources	47.7%	43.2%	55.5%
E. Educational level of trainees when entering the training program			
Less than B.S. degree	21.1%	1.8%	22.4%
B.S. degree or equivalent	57.8%	62.3%	65.0%
M.S. or Ph.D. degree	21.1%	35.9%	12.6%
Total	100.0%	100.0%	100.0%
F. Present educational level of trainees			
Less than B.S. degree	20.5%	–	17.5%
B.S. degree or equivalent	41.7%	16.2%	56.6%
M.S. degree or equivalent	27.6%	41.2%	19.6%
Ph.D. degree	10.2%	42.6%	6.3%
Total	100.0%	100.0%	100.0%

tional level. Although the IRRI research group is more highly educated—this factor may somewhat influence the type of research conducted (which appears to be the case)—this factor would not be expected to have a negative influence on the overall amount of work completed.

The second major difference is nationality and the possible influence of cultural factors on work behavior. The IRRI research group is primarily from countries in South, Southeast, and East Asia; whereas CIMMYT trainees are primarily from North Africa, the Middle East, South Asia, and South America. Because there was insufficient overlap between the two groups to measure the impact of nationality or culture on work

behavior, the importance of this influence remains unknown. However, based on the investigator's experience in agricultural training programs, where he worked with a wide variety of cultural groups, there was nothing in this experience to suggest that cultural background would have a *determining* influence on the type and amount of work performed.

Characteristics of Trainees in Their Work Organizations

The next set of variables to be examined in attempting to explain differences in the work behavior between the two research training groups concerns the role of the trainee in his work organization when the survey was conducted. Table 5 presents data on certain selected variables that could be expected to influence the dependent variable.

There is no difference between research groups regarding the level of their present positions in their work organizations, but there are other important differences which could directly contribute directly to the observed differences in work behavior. First, there is a substantial difference in the proportion of trainees doing field research work. Since the work behavior of IRRI research trainees tends to emphasize experimental field research (as reported in Table 5 and Fig. 1), the fact that only about 45 percent of the IRRI research group (contrasted with nearly 75 percent for the CIMMYT group) are engaged in field research would be expected to have an important negative influence on the mean level of field research activities completed per trainee. Second, the important difference between the two groups in regard to crops worked with (71 percent of CIMMYT trainees worked full-time on wheat research, whereas only 41 percent of IRRI research trainees worked full-time on rice research) would also be expected to have some influence on the total amount of wheat/rice research completed.

These findings raise two obvious questions: (1) why are there such large differences between the two research training groups with respect to these two variables; and (2) what actual impact are these differences having on the amount of work completed by trainees?

Although there are no clear-cut answers to the first question, certain facts are known. First, IRRI selects trainees from educational as well as research institutions for its research training program. With 16 percent of former IRRI research trainees now working in full-time teaching positions within agricultural colleges or universities, this group accounts for more than half the difference between the CIMMYT and IRRI research groups. Second, of those IRRI research trainees who are doing research work, more than one-third are engaged in laboratory/greenhouse research; this group accounts for the remainder of the difference.

Less easy to explain is the fact that only 41 percent of the research workers included in the IRRI research group are working full-time on

rice research, yet most come from countries totally dependent on rice as the major food stapel. The only apparent reason is that the IRRI research group is trained in disciplinary departments and is more highly educated, which again would be an impetus to further disciplinary

TABLE 5 VARIABLES DEPICTING THE ROLE OF TRAINEES IN THEIR WORK ORGANIZATION FOR ALL THREE TRAINING GROUPS

Characteristics of Trainees in Their Work Organization (when survey was taken)	CIMMYT Wheat Trainees (N = 130)	IRRI Research Trainees (N = 234)	IRRI Rice Production Trainees (N = 148)
A. Types of organizations where trainees are working:			
National research organizations	88.0%	56.9%	20.0%
National extension organizations	6.4%	1.9%	47.9%
Agricultural college or university	2.4%	27.3%	12.1%
Other	3.2%	13.9%	20.0%
Total	100.0%	100.0%	100.0%
B. Level of trainee's position in his work organization:			
Policy level	4.0%	4.7%	2.9%
Senior level	41.9%	46.5%	32.1%
Middle level	50.1%	45.0%	54.0%
Lower level	4.0%	3.8%	11.0%
Total	100.0%	100.0%	100.0%
C. Type of work trainee is engaged in:			
Mainly administrative work	11.6%	12.1%	22.7%
Mainly field research work	74.4%	44.7%	22.0%
Mainly lab./greenhouse research	6.6%	24.1%	3.8%
Mainly field extension work	5.8%	3.0%	28.8%
Mainly teaching or training	1.6%	16.1%	22.7%
Total	100.0%	100.0%	100.0%

TABLE 5 – *Continued*

Characteristics of Trainees in Their Work Organization (when survey was taken)	CIMMYT Wheat Trainees (N = 130)	IRRI Research Trainees (N = 234)	IRRI Rice Production Trainees (N = 148)
D. Crops worked with by the trainee in his job assignment:			
Only works with wheat/rice	71.4%	40.7%	32.8%
Works with wheat/rice and other crops	19.9%	31.5%	48.2%
Does not work with wheat/rice in his present job assignment	8.7%	27.8%	19.0%
Total	100.0%	100.0%	100.0%

specialization. Once back home in their national programs, which are concerned with several different crops (rather than a single crop as is the case with IRRI), it appears likely that these scientists may be called on to divide their research time with other crops in addition to rice. For example, a pathologist may be assigned to study fungus diseases of several economic crops rather than work on all different diseases of rice, such as bacterial blight, blast (a fungus disease), and tungro (a virus disease).

Trainees who have gone through the CIMMYT training program which operates within an interdisciplinary research structure, have tended to continue their focus on wheat improvement rather than specialize on research problems within a particular scientific discipline.

The second question raised above concerned the impact differences in trainee job assignments have on the overall work behavior of trainees. The procedure used to address this question contrasted the work behavior of two subgroups of trainees from each of the two research training groups—those mainly doing field research work and those working only on wheat/rice research—to determine if the observed differences in work behavior could be explained by either of these two independent variables, or if the differences still persist. Results of these analyses are found in Tables 6 and 7.

As the data indicate, the observed differences in behavior for those research activities most closely associated with the development of improved genetic and production technology (types C, D, and E) continue to be present even when considering just those subgroups mainly doing field research and those doing only wheat/rice research respectively.

TABLE 6 ANALYSIS OF VARIANCE OF WORK BEHAVIOR OF INDIVIDUAL TRAINEES MAINLY WORKING ON FIELD RESEARCH FOR CIMMYT AND IRRI RESEARCH TRAINING GROUPS†

Type of Activity Completed	CIMMYT Wheat Trainees (N = 79)	IRRI Research Trainees (N = 72)	*t* values	Level of Significance°
A. Laboratory and greenhouse experiments	1.76	0.61	1.1068	n.s.
B. On-station field research experiments	6.82	4.07	1.7757	n.s.
C. Genetic crosses	279.50	26.30	5.8646	**
D. On-station replicated applied research trials	8.95	2.00	4.3683	*
E. On-farm replicated applied research trials	4.95	1.68	2.4003	*
F. On-farm production plots	3.17	2.46	0.4226	n.s.

† Data reported is the mean level of each activity completed per trainee during the main wheat or rice growing season of 1972.

° The following statistical notations are used: n.s., not significant; *significant at the .05 level; **indicates the difference is highly significant at the .01 level.

Therefore, although a smaller proportion of IRRI research trainees are working in field research and a smaller proportion are only working full-time on rice research, thees differences in job assignments still do not explain the major differences in observed work behavior between the two research training groups.

To reiterate, it was not possible to account for the differences in work behavior between the two research training groups by considering the two main independent variables: (1) the differences in the personal background characteristics of the individual trainees in each group and (2) the characteristics of trainee job assignments in their work organizations. These findings, therefore, direct the inquiry to the intervening variable—the training itself—to see if the differences in training could account for the observed differences in work behavior.

TABLE 7 ANALYSIS OF VARIANCE OF THE WORK BEHAVIOR OF INDIVIDUAL TRAINEES WHO ARE ONLY WORKING ON WHEAT/RICE RESEARCH FOR THE CIMMYT AND IRRI RESEARCH TRAINING GROUPS†

Type of Activity Completed	CIMMYT Wheat Trainees (N = 81)	IRRI Research Trainees (N = 82)	*t* values	Level of Significance°
A. Laboratory and greenhouse experiments	1.72	1.12	0.5778	n.s.
B. On-station field research experiments	5.89	3.84	1.3358	n.s.
C. Genetic crosses	261.20	28.00	5.5943	**
D. On-station replicated applied research trials	8.36	1.52	4.4190	**
E. On-farm replicated applied research trials	4.43	1.26	2.6425	**
F. On-farm production plots	3.77	1.99	1.1194	n.s.

† Data reported is the mean level of each activity completed per trainee during the main wheat or rice growing season of 1972.

° The following statistical notations are used: n.s., not significant; *significant at the .05 level; **indicates the difference is highly significant at the .01 level.

Differences in Training As An Intervening Variable

The training objectives, methodology, and strategy of the two research training programs considered here are markedly different. Both training approaches were described earlier. The key points that appear to directly link them to the differences in work behavior are as follows.

IRRI has employed analysis as the main educational objective associated with the research project approach to training. In following this type of program, the trainee learns first-hand how to design, carry out, and report on a research experiment. In so doing, he learns how to think analytically—a prerequisite for any successful research worker. Having this ability and skill, however, does not prepare a research worker for all types of research work. In particular, he does not learn the research skills and methods associated with organizing and operating a research program aimed at developing improved agricultural technology where the primary

educational objective is synthesis (an objective that characterizes the CIMMYT wheat training program).

The CIMMYT wheat research program is essentially a highly organized "genetic assembly line" which has standardized procedures and routinized tasks to increase the efficiency and output of a wheat improvement research program while minimizing error. By systematically and effectively mixing the gene pool through large numbers of genetic crosses and by systematically screening the progeny of these crosses, particularly through the extensive use of early generation testing procedures (evaluation), the biological architects at CIMMYT believe they can maximize the probability of producing superior germ plasm. CIMMYT wheat trainees appear to have learned and adopted this research approach to wheat improvement, given their observed behavior.

The different approaches to research training pursued by IRRI and CIMMYT are having an important and measurable influence on the work behavior of research workers in less-developed countries. In the one case, research workers tend to emphasize experimental research aimed at generating new knowledge about rice production in the tropics. The other training group tends to emphasize and to be very efficient and productive in conducting research aimed at developing improved wheat technology.

Transforming National Research Capacity: A Postscript

As Ruttan and Hayami point out, one of the most serious constraints on the international transfer of agricultural technology is limited experiment station capacity for the production of biological technology.[30] The central theme of this study has been to analyze how two international research centers have addressed this problem through their training programs. In making this analysis, however, it became increasingly clear to the investigator that there was a more basic issue involved than just a difference in training objectives and methodologies. More important were the working assumptions made by each center concerning the ability of national research systems to organize their scientific resources. Although this is a complex issue, each center's response provides some valuable insights into the problem.

CIMMYT's response is essentially based on the premise that the national wheat improvement programs it is working with are not functioning effectively because they are unable to organize their scientific resources to solve practical production problems. The problem is essentially two-fold.

First is the problem of focus or research objectives. CIMMYT's response to this perceived institutional problem was to concentrate on one specific production problem—the need for improved genetic technology

—and through its training strategy to carefully and systematically build this relatively simple research function into each national program. Thus, organizational change was a specific, but implicit, training objective.

Second is the problem of functional integration, or the ability of a national program to effectively organize and mobilize its scientific resources around the objective of producing biological technology. By identifying this inability as a serious institutional problem, it follows that technical personnel, in addition to lacking relevant research skills and methods, would also lack the skills and spirit of working together in organized, cooperative team efforts. More precisely, they lacked the organizational skills and perspective necessary to integrate their research functions around a specific research objective. Thus, it was found that CIMMYT trainees in cereal technology spent one-fourth of their time in the wheat breeding program so they would clearly understand and appreciate the functional relationship between their work in cereal technology and in the breeding program. Likewise, each training group spent a substantial amount of time working in each of the other respective research programs that are functionally involved in developing improved genetic technology.

Following the logic of this strategy, it was expected that once a "critical mass" of trained research workers was present in a wheat improvement program, that program would function effectively. As this happened, it was expected that each national program would: (1) work out its own research structure (i.e., division of labor) to fit local needs and requirements and (2) take over the necessary informal on-the-job training of new personnel. Once this transformation had been achieved, CIMMYT expected national wheat improvement programs to be functionally competent to identify local production problems and meet long-term technological needs. Observations made by the investigator, while pretesting the survey questionnaire in the field, suggests that this strategy is working.

IRRI's response to the problem of how national research programs organize their scientific resources is based on a different policy decision. On one hand, IRRI officials and scientists expressed serious concern that some national programs lack the ability to organize and direct their research resources toward solving local production problems. On the other hand, however, IRRI leaders have expressed a sensitivity and concern that their international activities do not dominate the research capability of national programs.[31] By taking an explicit policy decision against direct institutional intervention, IRRI was then placed in a position taking, as a given, the ability of national programs to organize their scientific resources.[32] Furthermore, IRRI's research training strategy, while not resulting from this policy decision, is logically consistent with it.

IRRI is operating on the basis of the same type of institutional

relationship that a college of agriculture (as an educational institution) would have with a functionally effective experiment station (as a work organization). The college provides graduate students with a good theoretical background in a field of study, along with a solid research experience in designing, conducting, and reporting on a research project. Once hired by an experiment station for a particular research position, however, a student is given specific research responsibilities (tasks)—which are functionally integrated with the station's overall research program—that he is expected to carry out. Since it is unlikely that the student knows how to carry out these responsibilities, he will generally be assigned to work closely with a senior scientist in the same program. After a season or two of this informal, on-the-job type of training, the inexperienced research worker will develop sufficient skill competency to function independently in carrying out his assigned tasks.

IRRI, by using the research project approach and by training research workers in separate disciplinary departments, does not address institutional problems, such as poorly defined or inappropriate research objectives and the lack of functional integration, through its training strategy.[33] The observed work behavior of former IRRI research trainees, as they return home to concentrate on knowledge generating types of research, raises obvious questions about IRRI's training strategy. While trainees study production problems relevant to home country conditions, it appears that in most cases their research effort—as it contributes to the overall national research capacity—lacks sufficient emphasis on and attention to the problem of producing biological technology.

Conclusion

This study is built on the premise that as poor nations of the tropics and subtropics shift to modern agricultural production systems, they will need effective research institutions to meet long-term technological needs. Experience suggests that in some of these national research institutions, technology development research activities are frequently neglected[34] or are relegated to less qualified and/or motivated research personnel,[35] while more highly educated scientists concentrate on more theoretical research inquiries. However, if national agricultural research systems are to be relevant and useful to agricultural producers, then knowledge generating research activities must be, to a large degree, directed by and integrated with the technology developing research function. Furthermore, this technology developing research system must be capable of effectively and efficiently transforming new knowledge into improved agricultural technology. Where the national research capacity for producing biological technology is weak or lacking, then these national research systems will remain functionally impotent in their

ability to solve serious production problems; and these nations will remain largely dependent on external agencies (particularly the international research centers themselves) for new sources of improved technology. An analysis of the observed work behavior of former IRRI and CIMMYT research trainees supports the proposition that different training approaches (i.e., different educational objectives and training methodologies) and institution-building strategies can have an important impact on the type of national research capacity that develops. Therefore, international centers must be fully cognizant of these potential influences on the technological capability of national research systems when designing their training and outreach programs.

NOTES

1– V.W. Ruttan and Yigiro Hayami, "Technology Transfer and Agricultural Development," *Technology and Culture* 14:2(April 1973):124-5.

2– These international movements of wheat and rice varieties are well documented in Dana G. Dalrymple, "Imports and Plantings of High-yielding Varieties of Wheat and Rice in the Less Developed Nations," Foreign Economic Development Report No. 14 (Washington, D.C.: Foreign Economic Development Service, USDA in cooperation with U.S. AID, February 1972).

3– Both CIMMYT and IRRI made exotic and elite germ plasm available to cooperating national programs during this period; to some degree these efforts still continue.

4– Cf. *Building Institutions to Serve Agriculture* (Lafayette, Ind.: Purdue University, Committee on Institutional Cooperation, 1968), p.9; Willard W. Cochrane, *The World Food Problem* (New York: Thomas Y. Crowell Co., 1969), pp.218-19; A.H. Moseman, *Building Agricultural Research Systems in the Developing Nations* (New York: The Agricultural Development Council, 1970), pp.29-30.

5– Derek J. de Solla Price, "The Structures of Publication in Science and Technology," in *Factors in the Transfer of Technology*, ed. William S. Gruber and Donald G. Marquis (Cambridge, Mass.: The MIT Press, 1969), pp.94-97.

6– Sterling Wortman made this point rather succinctly: "That agricultural research must be undertaken at central experiment stations or in the laboratories of national research organizations or college of agriculture is well understood; frequently, however, the further steps of identifying and testing packages of technology in each distinct farming region of a nation and finally at the ultimate experimental site—the individual farm—are erroneously excluded." See Sterling Wortman, "The Technological Basis for Intensified Agriculture," in *Agricultural Development: Proceedings of a Conference Sponsored by the Rockefeller Foundation, April 23-25, 1969 at the Villa Serbelloni, Bellagio, Italy* (New York: The Rockefeller Foundation, 1969), p.31.

7– Biological architects are high-level research workers who develop improved biological technology. They are the "master builders" or the "research inventors" who manipulate and integrate new and/or different factors, materials, knowledge, etc. to create improved agricultural technology. In terms of a research hierarchy, the biological architect is on at least the same intellectual level as any senior research scientist. In fact, although the biological architect may use less sophisticated research tools, the cognitive or intellectual demands placed on him are frequently more complex than those problems faced by scientists conducting analytical research. Unfortunately, however, the technology developing function within the overall research process is generally considered (by the scientific community) inferior to the knowledge-generating function (science). Therefore, less talented research technicians are frequently assigned to these technology development roles, which may be one reason why many of these research programs, particularly in LDCs, have been so ineffective in producing improved agricultural technology.

8– Benjamin S. Bloom, et. al., *Taxonomy of Educational Objectives, Handbook I: Cognitive Domain* (New York: David McKay Company, 1956), p.144.

9– Ibid., pp.162-72.

10– Ibid., p.162.

11– Ibid., pp.185-92.

12– See Ruttan and Hayami, "Technology Transfer," pp.141-3.

13-- Cf. E.O. Heady, "Priorities in the Adoption of Improved Farm Technology," in *Economic Development of Agriculture*, ed. E.O. Heady (Ames: Iowa State University Press, 1965), pp.164-5; Hans W. Singer, "A New Approach to the Problems of the Dual Society in Developing Countries," *United Nations International Development Review* 3(1971):24; Lester Brown, *Seeds of Change* (New York: Praeger, 1970), p.52; and C.P. McMeekan, "What Kind of Agricultural Research?" *Finance and Development* 2:2(1965):73.

14– For a more detailed analysis of this problem, see Burton E. Swanson, "Training Agricultural Research and Extension Workers from Less Developed Countries" (PhD diss., University of Wisconsin, 1974), pp.18-42.

15– See H.L. Wilcke and H.B. Sprague, "Agricultural Research and Development by the Private Sector of the United States," *Agricultural Science Review* 5:3(1967):3.

16– Singer terms this condition "an internal brain drain"; ("New Approach," p.24).

17– This paper is concerned only with the training activities of IRRI and CIMMYT. For more information on IRRI, see *Rice, Science and Man* (Los Banos, Philippines: IRRI, 1972). For more information on CIMMYT, see Burton E. Swanson, *Institution Building: The International Wheat Technology Development and Transfer System*, in this volume. For general background information on international agricultural research organizations, see J.G. Crawford, "International Agricultural Research: An Encouraging Venture in International Collaboration" (Paper presented at the Conference on Resource Allocation and Productivity in International Agricultural Research, Airlie House, Va., 26-29 January 1975); and Nicholas Wade, "International Agricultural Research," *Science* 188(1975):585-9.

18– The following section is a brief summary of the training objectives and methodology employed by the CIMMYT Wheat Program. For more detailed information on this training program and an evaluation of this strategy, see Swanson, "Training," pp.101-87.

19– For a detailed description of this training methodology, see Dugan H. Laird, *Training Methods for Skills Acquisition* (Madison, Wisc.: American Society for Training and Development, 1972), pp.22-4.

20– See Swanson, "Training," pp.117-23, for detailed information about and examples of how CIMMYT attempts to achieve its attitudinal objectives.

21– The terms compliance, identification, and internalization are taken from and based on a theoretical framework of attitudinal change developed by H.C. Kelman, "Compliance, Identification and Internalization: Three Processes of Attitudinal Change," *Journal of Conflict Resolution* 2(1958):51-60.

22– The data used in this paper to analyze the performance of CIMMYT and IRRI trainees was based on an international survey of former participants conducted in 1973. Responses to mail questionnaires were obtained from more than 78 percent of the nearly 700 former trainees who had participated in one of the three training programs included in this study. A detailed analysis of these follow-up data for each training group can be found in Swanson, "Training."

23– Laboratory, greenhouse, and field experiments are defined in this paper as "knowledge generating" types of research; genetic crosses and on-station and on-farm applied research trials are classified as "technology developing" types of research. See Swanson, "Training," pp.14-18.

24— This conclusion is partially based on the assumption that individual research experiments take more time to plan and execute than applied research trials. The methodology of applied research trials can frequently be standardized and routinized to minimize time spent on planning, experimental design, and analysis.

25— The publication record for former CIMMYT trainees during the same period was that 39 of the 105 active wheat research workers had published or presented a total of 101 technical papers.

26— The rice production training program is specifically designed for rice extension workers. However, since one-fourth of the trainees in this program were research workers, this program is summarized briefly here.

27— An analysis of variance for the three technology development variables—for the two research groups depicted in Figures 1 and 2—indicates that these differences are statistically significant at the .01 level.

28— R.P. Lynton and Udai Pareek, *Training for Development* (Homewood, Ill.: The Dorsey Press, 1967), p.18.

29— To explain differences in the work behavior of trainees within training groups, I developed several different multivariate linear regression models, using key independent variables, in an attempt to predict different types and/or levels of work performance. None of the independent variables used in these analyses were found to have much influence (i.e., explain much variance) on the dependent variable.

30— Ruttan and Hayami, "Technology," p.124.

31— See Colin A. McClung, "IRRI's Role in Institutional Cooperation in Asia," *Rice, Science and Man*, p.38.

32— "The basic philosophy of these agreements was quite clear on an important point: they were in no sense intended to lead to the establishment of branch stations of the International Rice Research Institute. Rather, they were designed to foster improvements in the host countries' research and development programs. The degree and pace of IRRI's involvement *would be set by the decisions of local authorities* [emphasis added] and the work would be directed solely toward problems of concern to local rice scientists and rice farmers." Ibid., p.28.

33— It should be noted that several countries from which IRRI receives substantial numbers of trainees (e.g., Japan, Taiwan, Korea) are assumed to have rather effective research systems at the present time. Therefore, this type of research training may be quite appropriate in meeting their needs. However, if these programs are in fact relatively strong and functioning effectively at the present time, there would appear to be little justification for IRRI to expend its scarce training resources on research personnel from these countries, when the important rice growing countries of the tropics have weak research systems.

34— Moseman, *Building Agricultural Research Systems*, p.58.

35— Wortman, "The Technological Basis," p.21.

Appendix

TABLE 1 CIMMYT WHEAT NURSERIES DISTRIBUTION – 1974

Type of Crop	Name of Experiment	Africa (21 countries)	Asia (10 countries)	Central America (2 countries)	Europe (22 countries)	Middle East (12 countries)	North America (3 countries)	Oceania (2 countries)	South America (11 countries)	Subtotals by Experiment	Totals by Crop
BREAD WHEAT	Crossing Block (CB)	7	5	1	1	5	8	0	8	35	
	F2 Irrigated	12	17	1	7	4	18	0	10	69	
	F2 Dryland	10	16	1	8	5	15	0	15	70	
	F2 S x W	7	13	1	9	9	18	3	10	70	
	8th International Bread Wheat Screening Nursery (IBWSN)	33	24	2	17	18	19	4	20	137	
	5th Elite Selection Yield Trial (ESYT)	7	4	0	1	2	10	0	6	30	
	11th International Spring Wheat Yield Nursery (ISWYN)	22	18	1	24	13	24	2	16	120	
	5th International Septoria Nursery (ISEPTON)	8	1	1	7	3	8	1	5	34	
	3rd Multiline (8156)	7	8	0	0	3	8	0	4	30	
	Normal Height (F2, F3, & F5)	2	1	0	0	0	0	0	0	3	
	11th ISWYN (Short set)	1	0	0	2	0	2	1	0	6	
	Bread Wheat Subtotals	116	107	8	76	62	130	11	94		604

Table 1—*Continued*

Type of Crop	Name of Experiment	Africa (21 countries)	Asia (10 countries)	Central America (2 countries)	Europe (22 countries)	Middle East (12 countries)	North America (3 countries)	Oceania (2 countries)	South America (11 countries)	Subtotals by Experiment	Totals by Crop
	Crossing Block (CB)	5	2	0	1	7	0	0	2	17	
	F2	8	4	0	11	9	8	0	10	50	
DURUM WHEAT	F2 (Special sets)	4	0	0	0	3	0	0	0	7	
	6th International Durum Screening Nursery (IDSN)	13	5	0	20	17	17	1	12	85	
	5th Elite Durum Yield Trial (EDYT)	6	3	0	6	5	5	0	5	30	
	6th International Durum Yield Nursery (IDYN)	15	7	0	17	13	12	0	11	75	
	Durum Wheat Subtotals	51	21	0	55	54	42	1	40		264
	Crossing Block (CB)	4	5	0	1	3	6	0	6	25	
	F2 Irrigated	4	6	1	4	1	9	0	5	30	
	F2 Dryland	5	6	0	3	1	8	0	7	30	
	F2 S & W	1	3	0	9	0	12	0	5	30	
TRITICALE	6th International Triticale Screening Nursery (ITSN)	18	17	1	14	6	21	2	18	97	
	6th International Triticale Yield Nursery (ITYN)	15	11	1	13	7	17	2	9	75	

	1st Forrage Lines (FL)	6	1	0	2	3	12	2	4	30	
	2nd Triticale Disease Resistance Nursery (TDRN)	2	1	0	1	0	3	0	3	10	
	6th ITYN (Short set)	1	0	0	0	0	1	0	0	2	
	Triticale Subtotals	56	50	3	47	21	89	6	57		329
	Crossing Block (CB)	1	2	0	1	3	2	0	3	12	
BARLEY	F2	3	3	0	4	6	5	0	4	25	
	2nd International Barley Observation Nursery (IBON)	10	6	0	4	11	9	0	5	45	
	Barley Subtotals	14	11	0	9	20	16	0	12		82
	Totals by Geographic Area	237	189	11	187	157	277	18	203		1279

Source: Dr. Maximino Alcala, head of CIMMYT's International Wheat Nursery Program.

TABLE 2 INTERNATIONAL WHEAT NURSERY TRIALS BY COUNTRIES

Region & Country	1971	1972	1973	1974
AFRICA				
Algeria	8	24	40	49
Angola	0	0	0	4
Cameroon	0	1	2	2
Egypt	6	10	71	23
Ethiopia	12	17	27	35
Ghana	1	0	0	0
Kenya	5	8	14	13
Lesotho	2	1	2	2
Malagasy Republic	0	C	0	1
Morocco	16	6	27	16
Nigeria	1	0	3	9
Rhodesia	0	0	0	8
Senegal	0	1	4	4
Somalia	1	0	0	4
South Africa	6	8	30	17
Sudan	3	1	8	11
Tanzania	2	3	9	4
Tchad	0	0	2	3
Tunisia	21	24	27	27
Uganda	0	0	2	1
Zaire	0	0	0	2
Zambia	0	0	2	2
Totals:	84	104	270	237
ASIA				
Afghanistan	3	6	13	10
Bangladesh	17	1	5	6
China	0	1	0	0
India	20	30	98	90
Indonesia	0	0	2	1
Japan	1	1	4	4
Nepal	0	6	7	15
Pakistan	3	21	45	47
South Korea	0	5	12	10
South Vietnam	0	0	0	1
Thailand	3	1	5	5
	47	72	191	189

Table 2—*Continued*

CENTRAL AMERICA				
Guatemala	4	7	12	10
Honduras	0	0	1	1
Totals:	4	7	13	11
EUROPE				
Albania	0	0	0	5
Austria	0	0	4	3
Bulgaria	1	1	5	4
Czechoslovakia	0	0	0	1
Denmark	1	2	5	8
England	5	3	12	14
Finland	0	0	1	3
France	2	2	15	18
Greece	1	1	5	9
Hungary	1	2	5	10
Ireland	0	0	0	1
Italy	7	1	4	9
Netherlands	1	0	2	5
Norway	1	0	0	0
Poland	5	4	6	17
Portugal	5	6	9	10
Romania	5	4	8	8
Russia	3	8	34	20
Spain	7	5	12	22
Sweden	3	5	3	3
Switzerland	4	2	2	3
East Germany	1	0	0	0
West Germany	1	1	1	2
Yugoslavia	4	3	10	12
Totals:	58	50	143	187
MIDDLE EAST				
Cyprus	1	1	12	10
Iran	8	10	23	20
Iraq	3	10	0	7
Israel	7	10	11	11
Jordan	3	7	0	11
Lebanon	20	18	32	27
Libya	1	5	0	8
North Yemen	0	0	0	4
Saudi Arabia	0	0	0	4

Table 2—*Continued*

South Yemen	0	0	0	5
Syria	2	0	0	13
Turkey	25	35	38	37
Totals:	70	96	116	157
NORTH AMERICA				
Canada	11	13	25	39
Mexico	49	63	87	149
U.S.A.	62	82	81	89
Totals:	122	158	193	277
OCEANIA				
Australia	5	2	9	13
New Zealand	4	3	3	5
Totals:	9	5	12	18
SOUTH AMERICA				
Argentina	28	46	68	69
Bolivia	0	2	3	9
Brazil	17	35	51	40
Chile	7	20	26	23
Colombia	5	10	11	9
Ecuador	5	8	13	16
Guyana	0	0	1	1
Paraguay	0	6	6	7
Peru	6	14	20	24
Uruguay	1	4	2	3
Venezuela	0	0	1	2
Totals:	69	145	202	203

Source: Dr. Maximino Alcala, head of CIMMYT's International Wheat Nursery Program.

TABLE 3 SIZE AND TYPE OF INTERNATIONAL WHEAT NURSERIES BY YEAR

BREAD WHEAT NURSERIES

Year	No.	Lines	Reps.	No. of Sets	Bulletin
International Spring Wheat Yield Nursery (ISWYN):					
1964	1st	25	3	34	Yes
1965	2nd	25	3	70	Yes
1966	3rd	50	3	80	Yes
1967	4th	50	3	80	Yes
1968	5th	50	3	80	Yes
1969	6th	50	3	80	Yes
1970	7th	50	3	90	Yes
1971	8th	50	3	100	
1972	9th	50	3	100	
1973	10th	50	3	120	
1974	11th	50	3	137	
International Bread Wheat Screening Nursery (IBWSN):					
1967	1st	1216		15	
1968	2nd	1355		20	
1969	3rd"a"	287		25	
1969	3rd"b"	1125		30	
1970	4th"a"	270		40	
1970	4th"b"	1150		55	
1971	5th	336		65	
1972	6th	315		100	
1973	7th	330		120	
1974	8th	500		140	
Elite Selection Yield Trial (ESYT):					
1970	1st"a"	25	4	20	
1970	1st"b"	25	4	20	
1971	2nd"a"	25	4	20	
1971	2nd"b"	25	4	20	
1972	3rd	25	4	15	
1973	4th	25	4	20	
1974	5th	25	4	30	
Spring Wheat X Winter Wheat Segregating Populations (F_2 S X W):					
1973	1st	*		25	
1973	2nd	*		10	
1974	3rd	315		10	

TABLE 3—*Continued*

Latin American Disease and Insect Screening Nursery (LADISN):

Year	No.	Lines	No. of Sets	Bulletin
1972	1st"a"	794	20	*
1972	1st"b"	939	10	*
1973	2nd	557	30	*
1974	3rd	*	*	*
Regional Disease and Insect Screening Nursery (RDISN):				
1970	1st	1800	6	*
1971	2nd	2400	10	*
1972	3rd	2400	40	*
1973	4th	2400	40	*
1974	5th	2400	40	*
International Septoria Nursery (ISEPTON):				
1970	1st	76	15	
1971	2nd	108	25	
1972	3rd	155	25	
1973	4th	131	25	
1974	5th	*	*	
Multiline Nursery (8156):				
1973	1st	285 1	30	
1973	2nd	291	30	
1974	3rd	256	25	
1974	4th	*	*	
Crossing Block:				
1973 (June)		255	25	
1973 (Nov.)		350	10	
1974 (June)		264	35	
1974 (Nov.)		*	*	

Segregating Populations (F_2):

Year	Populations	No. of Sets
1973 (Dryland)	*	75
1973 (Irrigated)	*	75
1974 (Dryland)	*	70
1974 (Irrigated)	*	70

DURUM WHEAT NURSERIES

International Durum Yield Nursery (IDYN):

Year	No.	Lines	Reps.	No. of Sets	Bulletin
1969	1st	16	3	50	Yes
1970	2nd	25	3	50	Yes
1971	3rd	25	3	50	Yes

TABLE 3—*Continued*

Year	No.	Lines	Reps.	No. of Sets	Bulletin
1972	4th	25	3	50	
1973	5th	25	3	75	
1974	6th	*	3	*	
International Durum Screening Nursery (IDSN):					
1969	1st	138		20	
1970	2nd	232		35	
1971	3rd	256		40	
1972	4th	223		55	
1973	5th	165		75	
1974	6th	244		85	
Elite Durum Yield Nursery (EDYN):					
1971	1st	25	4	25	
1971	2nd	25	4	25	
1972	3rd	25	4	25	
1973	4th	25	4	25	
1974	5th	25	4	30	
Crossing Block:					
1973	1st	*		3	
1974	2nd	*		*	

Segregating Populations (F_2):

Year	No.	Populations	No. of Sets
1973	1st	*	80
1974	2nd	69	50

TRITICALE NURSERIES

International Triticale Yield Nursery (ITYN):

Year	No.	Lines	Reps.	No. of Sets	Bulletin
1969	1st	16	3	50	Yes
1970	2nd	16	3	50	Yes
1971	3rd	25	3	50	Yes
1972	4th	25	3	50	
1973	5th	25	3	75	
1974	6th	25	3	75	
International Triticale Screening Nursery (ITSN):					
1969	1st	47		25	
1970	2nd	70		30	
1971	3rd	75		50	
1972	4th"a"	108		40	
1972	4th"b"	123		40	
1973	5th"a"	100		50	

TABLE 3—*Continued*

Year	No.	Lines	Reps.	No. of Sets	Bulletin
1973	5th"b"	100		50	
1974	6th	*		100	

Segregating Populations (F_2)

Year	No.	Populations	No. of Sets
1973	1st	150	30
1974	Irrigated	126	30
1974	Dryland	175	30
1974	S X W	50	30

Other Nurseries:

Year	Type	No. of Sets
1973	Crossing Block	10
1974	Crossing Block	30
1974	Forage Line Nursery	30
1974	Triticale Disease Resistance Nursery (TDRN):	10

BARLEY NURSERIES

International Barley Observation Nursery (IBON):

Year	No.	Lines	No. of Sets
1973	1st	381	20
1974	2nd	163	35

Crossing Block:

1973	1st	*	1
1974	2nd	*	3

Segregating Nurseries (F_2)

1973	1st	56	20
1974	2nd	*	25

Source: Dr. Maximino Alcala, head of CIMMYT's International Wheat Nursery Program.

* Complete Information for 1974 was not available when this study was prepared.

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