# CIMMYT RESEARCH: EXTENDING THE GAINS

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## INTRODUCTION

Many ideas have been discussed during the past two days. Before talking about their implications for CIMMYT, I want to review briefly some enduring aspects of our history and to comment on some of the changes that have occurred during the past twenty years. The two combine to make today's CIMMYT both the same and yet different from the CIMMYT of 1966. I will then go on to talk about how we see the near future, incorporating many of the ideas of the workshop. I add that in 1987 and in conjunction with an External Program Review, we will formulate a five year plan. It is in that effort that the discussions of the workshop will have their greatest influence.

## A LOOK TO THE PAST

### Hallmarks

As CIMMYT emerged from a joint Rockefeller Foundation/ Mexican research effort, our staff in 1966 was made up of practiced veterans. That staff has grown larger and its composition and deployment has changed. Even so, certain things have stayed very much as they were in the earliest days. These are the hallmarks by which the Center is known.

First, and most importantly, the ethos of today's CIMMYT remains very much what it was at our inception. Its essential elements are an emphasis on field work, on the importance of direct researcher involvement, on a pragmatism based on the needs of farmers, and on the benefits and obligations of an open association with a

worldwide network of practitioners sharing the same principles. As at its beginnings, CIMMYT's operations still rest on these ideas.

Second, throughout our history we have played our role in concert with national programs. Those programs are the Center's clients. We see ourselves as agents for complementing their work, thereby facilitating their efforts to serve their own clients, the farmers. We do that by providing national programs with germplasm, training, research procedures, counsel, and information.

Third, the Center is recognized and treated as being above politics. Over the years it has always responded to the needs of national programs without the limitations that might have been imposed by its individual donors. National programs have long recognized that stance and have no reservations about sharing through CIMMYT nor about CIMMYT's willingness to share with them. This evenhandedness is a continuing CIMMYT hallmark and the resulting trust is one of CIMMYT's most valued assets.

Fourth, like others in the CGIAR system, we see the clear advantages in the long horizons and sharp focus of our research. The two combine to bring patience and care in the pursuit of well-defined research themes. That blend contributes notably to CIMMYT's success, as it did to the successes of our predecessors.

Finally, our evolution continues to be conditioned by a commitment to multi-disciplinary research. We see great advantage in the combining of disciplines, practice it ourselves, and advocate it for national programs.

These, then, are the characteristics that make today's CIMMYT like the CIMMYT of 1966.

## Impacts

You will all know of CIMMYT's substantial contributions through germplasm--some 70,000,000 hectares are currently cultivated with varieties related to CIMMYT and its predecessor's efforts. You may not be as aware of our other contributions to developing country agriculture. Some 4,000 national program researchers work more effectively thanks to the impressions and skills acquired through training sponsored by CIMMYT. And they are able to draw on an expanding array of research techniques and procedures fashioned through CIMMYT's accumulating experiences in research and training. The training and the procedures notably enhance national program efforts.

While hectares of land, trained researchers, new methods, and productive partnerships reflect much of the impact of the decades of effort, there is more. Also important, albeit even more difficult to measure, is an influence on spirit and on attitude. An awareness of the potential impact of agricultural research now shapes the attitudes of those concerned with economic development and its policy. Having seen the potential through such research, these decision makers are ever more open to arguments for investment in agricultural--in its supporting infrastructure, in rationalizing its policy, and in fortifying its research. And this positive stance enhances the possibility of change within the sector.

## New Views

Over time our perception of the process of agricultural research and the sector's development has evolved. In an earlier day, conventional wisdom saw agriculture as a source of resources which could be drawn away to more productive pursuits elsewhere. Today's view is that agriculture itself can cause widening circles of growth within the rural and the urban communities of developing countries. With higher productivity from new technologies, incomes increase to those who hold the land, labor, and capital of agriculture. Higher incomes favor added spending, which induces still more spending by its recipients. Agriculture initiates these rounds of growth. This perception, with its emphasis on resource productivity, has implications for the allocation of research resources, implications still being explored by today's research managers. Our Economics Program will further our understanding of these relationships.

Over the years changes have occurred in the nature of CIMMYT's partnerships with national programs, bringing ever more prominence to their role. In germplasm development more segregating materials are distributed than in an earlier day, and more resources are committed to joint ventures focused on particular problems; examples include cooperative research with Brazil to develop aluminum tolerant wheats and with Thai researchers for downy mildew resistant maizes. In husbandry the balance has swung away from the direct pursuit of technologies for specific areas towards expanded training for national program practitioners so they might more effectively forge new technolgies for farmers.

CIMMYT is giving new attention to its own priorities. Some of this has led to more precise understanding of the relative demands for the various classes of maize and wheat. This point was raised by Dr. Arnold and by Dr. Borlaug in their papers and is implicit in one of the challenges signaled by Chairman Husain. Both crop programs are well along in delineating major environments, so called "mega-environments," and in estimating the relative size of each. This effort will give CIMMYT a clearer sense of the needs of its clients, hence of its own priorities.

And ever more energy goes to strengthening the capacities of national programs through training in research techniques, in problem identification, and in priority setting. These were, of course, concerns in an earlier day but emphasis has grown through the years, especially with the advent of CIMMYT's regional programs in the mid-1970s and their expansion through the last decade.

What all of this says is that CIMMYT is an institution that combines constancy in its hallmarks with fluidity in its activities as circumstance and accumulating experience point the way to new opportunities. We remain an up-to-date institution with enduring traditions.

# THE FUTURE

And what of the future? What will be the themes of tomorrow? Consider first several of the circumstances that will shape our environment.

## Tomorrow's Environment

First, we recognize the importance for our work of the current emphasis on productivity. We also recognize that growing international trade in agricultural commodities has implications for the orientation of national program research, hence for our undertakings as well. We see the importance and the difficulty in identifying comparative advantage in today's open economies. These points were raised in the paper by Dr. Schuh. We see growing strength in some national programs and recognize that this presents the CG system with new opportunities through recombining resources and tasks. We believe that new science will bring new opportunities to complement conventional approaches. We can hope that national policies will favor increasing investment in well-directed research, through judgement based more on biology and resource endowments, ever less on whim or misapprehension. Finally, we understand that if desired rates of economic development occur, an ever higher proportion of our products will be destined for livestock feed with strong implications for the demand for maize and wheat.

Having said this, what about the direction of CIMMYT's work? What aspects of our research portfolio will show the most change? My own sense of evolving balances in our research agenda suggests changes in working relationships, germplasm, new science, enhancing human capacities, and our work for Africa.

## Working Relationships

CIMMYT has a wide range of working relationships with national programs, with institutions, with development assistance agencies, and with individuals. It seems likely that current forms will continue into the future, with more emphasis on some, less on others; some new relationships with new formats will also be developed. I want to talk about three formats that might well gain added prominence in the next decade.

The first of these is exemplified by an association now working on barley yellow dwarf virus. While BYDV can have dramatic effects on yields, its impacts are usually small, but widespread and regular. The virus was identified in 1951 but little concerted work was done before the 1970s.

A worldwide conference on BYDV held here in 1980 helped to shape an international network of researchers concerned with various aspects of the disease, ranging from interest in the virus and resistance mechanisms through breeding and on to germplasm evaluation. Funding for the network has come from several donors, with the Italian Government bearing the bulk of the current costs. A CIMMYT staff member serves as a liaison person among the researchers and brings results to bear through our own spring bread wheat program and the barley breeding program of ICARDA. What is appealing about this network is its wide range of scientific competencies,the way in which results are transmitted, the participation of researchers from developing and developed countries--each contributing according to particular advantage--and its close connections to active breeding programs. We expect to see more such networks in the feture, bringing the elements of the global scientific community together around a particular problem and with strong connections to practicing plant breeders.

In the planning stages is a similar form of networking-similar in the sense that scientists from several countries are involved and their efforts are focused on a particular problem, albiet one less extensive in its geographical sway. One application could focus on the problems--such as weeds, fertility, soil structure and tilth, and salinity--inherent in sustaining yield increases in the ever more intensively used lands under rice wheat rotations from Pakistan through to Bangladesh. In this application the focus is beyond agronomy and technology generation; it will look through science at the underlying relationships on which sustainable yields must be based. Such networks might plan joint research, partition problems according to competencies, share data and analysis, and ensure the professional and technical quality of the research itself.

A third format would see some of the activities currently in the hands of CIMMYT transferred to well-established national programs. Much of this has already happened, of course; the adaptive and applied agronomy of technology generation is now largely in the hands of national programs and a growing proportion of CIMMYT's nurseries, especially in wheat, are made up of varieties developed by national programs. Still, there is the possibility that other activities could be shifted to national programs. Some, for example, point to training and make the case that training for the professionals of a given region could be offered by that region's more advanced national programs. CIMMYT's role here might be in providing training materials and in supporting the teaching staff. Other examples will occur to many of you. CIMMYT will be looking further into this format, exploring with national programs and the CG the feasibility and the desirability of such devolutions.

CIMMYT, indeed the IARCs, play a critical, and I would guess an underesteemed, role in many networks. That role rests on the perceptions that the Centers are not only efficient but are truly evenhanded in the distribution of materials and ideas. That conviction is essential to effective networks. It is also essential to ensuring the CG system's continuing productivity.

## New Science

We are all aware of the startling developments in science as molecular biologists, biochemists, and others have brought their discoveries to bear on issues in plant improvement. CIMMYT has moved in deliberate ways to take advantage of these developments and has established consulting and professional relationships with leaders in these and related fields.

We have done so because, like others, we are impressed with the advantages latent in the new techniques and feel it is only prudent to take steps to assure access to unfolding developments. One such step is to add a molecular biologist to our staff and, over time, to bring into play the physical and organizational infrastructure necessary to support the activities we envision.

Our thinking about the extent to which CIMMYT should invest in new science is shaped by three considerations: First, we see ourselves applying the techniques others develop, we are more tool users than tool makers; second, we must ensure that CIMMYT is able to employ new findings in the practice of plant breeding as these become applicable; third, we recognize that, beyond CIMMYT's own requirements, national programs look to us to assure their access to the new technique for application to their work.

Our current collaborative work using the new tools of plant breeding focus on tissue culture, concentrating on finding new ways to maintain and multiply the hybrids emerging from our wide cross programs; on callus work to induce chromosonal breakages; and electrophoresis to identify the extent of gene transfer occurring through intergeneric and interspecific crosses. The work currently underway is aimed at bringing traits out of wild relatives into maize and wheat. Our special concerns are selected disease and stress conditions. These efforts conform well with the optimisms of Professor Frey.

As we see it, one other major new technology appears to be applicable to CIMMYT's work, the use of gene probes. These could be used to screen large amounts of material in the laboratory, reducing the need for large field experiments; for diagnosis, such as in ascertaining the presence of a virus; and to assess the success of efforts to transfer alien genetic material. And perhaps, just perhaps, we could become the repository for such probes or clones as they are developed, both by ourselves and by others around the world.

While much has been promised by those who pursue the applications of new science to plant breeding, there are grounds for caution. For example, while genes can now be transferred and spliced, those in maize and wheat have not yet been mapped for function. Moreover, regeneration is still more an artform than a science. Until these challenges are met, the techniques related to splicing have limited applications for CIMMYT.

There is much to suggest that we make haste slowly. Even so, I am impressed by the commitment that major private plant breeding companies are making in this field, with some reporting as much as 10-15% of their research resources devoted to biotechnology. And, too, we are mindful of Thomas Huxley's observation that "a customary fate of new truth is to begin as heresy and end as superstition."

As the chorus claims, it is a fast breaking field. We must organize so as to ensure that we know which developments are relevant to our needs and can move quickly to incorporate them. This will require not only expertise in the field of biotechnology and a recognition of the practicalities of conventional plant breeding but, as well, sufficient sympathy and familiarity that an augmented supply of science finds a responsive demand. The steps that we are taking are designed to serve those ends. Like Lloyd Evans we see a continuing central role for conventional breeding and, to the extent desirable, we want to augment its efficiency through relevant new tools.

## Germplasm

As in the past, germplasm will remain CIMMYT's major product. Our work in germplasm development has tended to favor the better environments of developing countries. This is most true for wheat, where much of the attention of the past has been on well-watered areas. That emphasis, by the way, was quite appropriate given that some two-thirds of the developing world's spring wheat is grown in such environments. Most tropical maize, on the other hand, is grown in the presence of significant environmental threats, with the well-watered areas suffering the menace of disease and insects while the drier areas encounter the dramatic effects of drought. Overall progress in bread wheats, durum wheats, maize, and triticales has ranged from remarkable to extraordinary. And what about the future?

In deciding the emphasis of the future we must recognize the importance of the favored environments while, consistent with the 1986 TAC Priorities Paper, we cater more to the needs of the more difficult environments. In deciding on the relative importance of each we must integrate the differing effects on economic development of new technologies, enhanced productivity, and increased income flows, along with the probability of achieving results.

As we view research on wheat for well-watered areas, emphasis will be placed on maintaining the gains achieved. More generally, and other things equal, greater attention will be given to materials for more difficult environments. In this judgement we are more like Dr. Frey than Dr. Evans. Even if the probable gains were less in the poorer environments, a concern for the poorest, coupled with the perception that they tend to occupy the most difficult environments, would still be cause to focus on these areas. I add that we cannot yet say much about the final effects, after added rounds of spending, of given productivity changes in the two environments. Evidence on the relative size of such parameters must rate a high priority for economists.

Major efforts are now underway on materials that can accommodate drought stress. Work in the maize program was initiated several years ago, then put aside, and is now again receiving a major emphasis. Interestingly, this research tends to show that maize selected under both drought stress and well-watered conditions tends to perform much better under drought stress and somewhat better in well-watered circumstances than does maize selected only under well-watered conditions. Work on spring bread wheat, on durum wheat, and on triticale is also well along and we expect good results given the resources being committed.

It should be noted that there is not complete agreement on the most expeditious way to approach the drought stress issue for small grains. To the extent that disagreement can serve as a source for hypotheses, we expect our efforts to sharpen understanding of the preferred way to undertake such work as well as to develop improved genetic materials. Soil problems in several important maize and small grain environments severely limit productivity. Work undertaken in close collaboration with Brazilian wheat specialists is well along for bread wheats that can tolerate otherwise toxic levels of aluminum. Similar work, focusing on maize and involving several Latin American programs, is being launched.

Work is underway on wheat for more tropical environments and good progress, indeed surprising progress, has been made. One aspect of that work involves resistance to diseases that, while common to such environments, are less commonly

encountered in traditional wheat-producing areas. As well, and with probable beneficial impacts for selected areas already producing wheats, work is underway that will result in more late heat tolerance for wheats.

For both maize and wheat there is an expanded effort on earliness. This characteristic offers two advantages. The first is to permit escape from diseases or heat or drought. The second, and one becoming ever more widely recognized, is that earliness enables more intensive cropping, implying more options for farmers.

In reaching for these goals--earliness, tolerance for heat and drought, accommodation to problem soils, and new classes of disease resistance--CIMMYT breeders frequently work directly with concerned national programs. Those relationships will be enlarged and fortified as this class of work expands.

In assessing these lines of work, we are convinced that, via the farm level, we can come to know more about issues of importance in priority setting and policy making and are investing, especially through the Economics Program,

in acquiring the needed understanding. Combining these insights with those from a more global perspective should help us and our national programs colleagues to have a clearer sense of priorities.

Also with respect to germplasm, we have greatly augmented our capacities to serve as curators of selected portions of the world's germplasm of maize, durum and spring bread wheats, and triticales. Again, as in so many cases, fulfilling our responsibilities in this area will involve us in collaboration with several national programs, especially in Latin America for maize germplasm. A substantial portion of the desired materials is in storage and we are developing the associated data. After periods of anxiety and, I think, no little confusion, it is satisfying to report that machinery will soon be in place to satisfy a well-defined portion of the world community's needs.

**Professional Training**

CIMMYT and its predecessors have invested heavily in supporting the efforts of National Agricultural Research Systems (NARS), with a primary part of this effort expended in augmenting human capital through various kinds of training and consulting. As a measure of this, a recent survey of wheat program staff suggests that as much as 45% of their total effort can be ascribed to these activities. The marvelous new facility we just inaugurated is itself a testimony to our commitment. We will continue that emphasis in the future but will redirect some of the energies.

Before reviewing potential new allocations in training, there are components whose continuance should be reaffirmed. I refer here especially to the in-service training programs in plant breeding. There is a clear advantage in offering that training here in Mexico as in the past. An important element in that judgement is simply that current levels of participation are close to those required in order to meet the demands of developing countries. This is not to suggest that we will fully satisfy those demands; replacements due to retirement and career changes will ensure a continuing need for such training. On balance, however, our annual capacity approximates the average annual needs of our client countries. And the evidence argues forcefully that these Mexico-based programs are both effective and efficient in supplying such training.

We must, however, find ways to multiply the energies we are investing in training on agronomy and technology generation. The demand for these skills in developing countries is enormous compared with the training capacities of the IARCs. We have moved in this direction through an expansion in our in-country training efforts. In time we hope to see more of this training in the hands of national programs themselves, or being offered on a regional basis under the auspices of the more mature national programs. If this occurs, CIMMYT would supply course structures, training materials, counseling on conducting the training and, at times, staff to participate in such programs. Even so, in-service training in production agronomy would go forward in Mexico, perhaps at a modestly reduced scale, to serve as a vehicle through which NARS training capacities could be developed, new materials formulated, and new concepts pursued. An enduring characteristic of this work is the representative farmer at the center of the effort.

As in the past, efforts in training will rely heavily on learning by doing. However, given new developments in instructional materials and a clearer understanding of their potential role, we are moving to develop more such material. In this case we ourselves are learning by doing as we discover the applications of supporting materials to reinforce the lessons of the crossing-block, the breeders' plots, and the fixing of priorities for production trials.

We have long had a program for visiting scientists in which we welcome colleagues from NARS to work alongside our staff, at times in pursuit of particular research themes and at times more to familiarize themselves with specific methods or materials. This too will continue. Beyond this, we are adding the opportunity for participants to refurbish research skills. Our plan is that participants will remain here for four to six months, most of them with data from projects undertaken at home. We will provide the opportunity to analyze, to pursue related research through the library, and to write research reports. This will meet a need forcefully expressed by many of our colleagues: that results are not available to peers because researchers do not have the time to analyze and write and that certain research skills atrophy because of that same constraint. Interest in this program is widespread and we have had extraordinary financial support from donors and from the private sector. Our new facility will play a crucial role in this undertaking.

Finally, we see a growing need for new specialized courses focused on a single or on closely related themes, like that offered in pathology and funded by the Dutch. These would be designed and developed in Mexico, based on the experience of network colleagues and our own staff, and made portable so that they, too, could be offered on a regional or national basis.

Our work in training has done much for human capital formation in agricultural research. What is too little appreciated is what it can do for CIMMYT itself. First, we have the opportunity to learn from the accumulated field experiences of participants in those programs. Beyond that, and largely unrecognized, training staff, with their own periodic involvement in research and continuing close connection to the research of others, are a vehicle through which CIMMYT's

experience is synthesized, impressions formed, and procedures are formulated and improved. These procedures, in turn, are basic to the development of training programs. It is in training then, that CIMMYT wide experience can be gathered, integrated, and then framed in concrete terms.

## Work for Africa

Already sharply increased through special projects with USAID and CIDA, Canada, we see an increasing proportion of our energies over the next decade being focused on activities related to sub Sahara Africa. Our commitments there will surely be larger than that implied by the areas of maize and wheat--some 18% and 6% of developing country maize and wheat--or even by that of the proportions of populations dependent on the two crops would imply. They will be small, however, when measured in terms of the need for support and in terms of potential impact.

This work will be representative of the full range of products that CIMMYT delivers to national programs. A considerable portion of the effort will be in germplasm development. Given the urgency of the food and income problem, we have moved our work on intermediate altitude maize to Africa, are now planning to strengthen our forces working on germplasm for the humid and subhumid tropics, and are contemplating a shift to bolster efforts related to maize's capacity to accommodate drought. In doing this we expect a substantial cooperation with IITA, with France's IRAT, with the newly formed SPAAR, and with other teams being deputed to the region by donors to the CGIAR.

We have every faith that African farmers will move to take up appropriate new technologies. Recent evidence from Ghana, where CIMMYT staff have worked with the national program through a bilateral project funded by CIDA Canada, supports that faith. In a survey of maize farmers, high rates of adoption of improved varieties introduced from the international maize network, of nitrogen fertilizer, and of new seeding patterns were strongly evident in selected areas. There will be more evaluation of the Ghana experience in the near future and of other such activities in time.

Training efforts in Africa will also be fortified. It is our hope that a significant portion of the training required, most notably that related to production agronomy, will be undertaken within African programs. As Dr. Thomas Odhiambo has said "The vital question. . is the development of locale specific technologies that permit continuous crop production over many years." Training in production agronomy will be critical to this effort. Kenya is already moving towards developing a national training capacity and we expect that other national programs will adopt similar strategies in the near future. CIMMYT can support such ventures through the preparation of related training materials and through working with national program training staff. Efforts are underway and we expect to see more resources committed to such work over the next three years. With respect to CIMMYT's training activities, it is interesting to note that the number and proportion of trainees from Sub-Sahara Africa increased over each of CIMMYT's quinquennials. Moreover, the proportion of trainees in breeding has declined while those in agronomy have increased.

In our view there is considerable scope for working with national programs in planning and assessing the directions of their work on maize and wheat. This kind of counseling could contribute much to the efficiency with which notably scarce national resources are used. In reflecting on priority setting within national research programs, there are many cases in which it is relevant to ask if too many or too few resources are devoted to maize or wheat research. Such decisions, of course, are properly in the hands of national program leadership: even so, we can provide pertinent information. As well, in collaboration with such newly emerging entities as SPAAR, CIMMYT staff will be good sources of information about high-priority potential investments for donors in the activities of national programs.

Finally, we see ourselves as more actively engaged in direct collaboration with other IARCs whose mandates include work for Africa. One potential form of such collaboration is in research on technology generation involving several IARCs and relevant national programs. While we believe that others could do this job, there are two considerations that argue for our active participation. The first is the overwhelming urgency of the need for improved technologies appropriate to the circumstances of African farmers. The second is that African support for research in

Africa would be substantially fortified by examples of successful applied or adaptive research.

## SUSTAINING MOMENTUM

By any standard of measurement the CG system must be regarded as a marvelously successful venture. The recently concluded CGIAR Impact Study gives ample evidence of this. One welcome result of the Study is that it should quiet apprehensions about the distribution of the benefits from IARC research. The evidence shows widespread benefits, especially to poor consumers, and that should be a comfort to those who were concerned about benefit flows. This is not, of course, to suggest that all is well on the income distribution front, but rather that the earlier, more strident critics seem to have been well off the mark.

But how can CIMMYT and the CGIAR best maintain the momentums that have contributed so substantially to agriculture in developing countries? The earlier discussion makes the case that the spirit of innovation must hold sway, not just in research itself, but also in contributing to new forms and structures in collaboration, in product, in training, and in procedures.

Sustaining momentum relates not only to support for the IARCs but as well to bolstering support for the national programs of developing countries. During CIMMYT's short 20 years we have seen that support oscillate, first for one institution and then another. We know that constancy strongly influences the utility of research and that on-again, off-again support seldom leads to acceptable payoffs. We also know that sustained support will probably only come after national decision makers are convinced that they cannot do without agricultural research, that their constituents will challenge their judgement if support is inadequate. And we know as well that those convictions can only come if national programs can give clear evidence that an investment in their work is an investment with high payoffs.

CIMMYT, too, must maintain its energies, and do so in the face of ever more subtlety in our understanding of the potential through research. The convictions of an earlier day were maintained by rallying cries that gripped the imagination--"Food for hungry bellies." Today's shibboleths sound faint and pedantic by comparison. We must also, even with the increasing emphasis on new science, maintain the luster of more conventional forms of research, forms that will surely provide the gains of the next decade and more. And finally, in the face of apparent abundance, we must gather the energies to add choice to the lives of the desperately poor.

Surely these are formidable challenges, but this is not at all to suggest that this is the end; to paraphrase Winston Churchill, it is not even the beginning of the end. But it may well be the end of the beginning, in the sense that the circumstances of our next two decades will differ markedly from those of the last two. With the experience, the energy, the wit, and the innovative spirit of our staff, I have no doubt that we will reach new highs, with an expanding array of viable options to national programs and, through them, to farmers.

Gatherings like this--gatherings in which we pay high honor to our past and remind ourselves of how we came to be as we are--are essential to maintaining our momentum. Just as surely, guiding that momentum depends upon such workshops as this, where we tap the deliberate reflections of the knowledgeable.

Our opportunities are at hand; I know that you share my confidence in their realization.