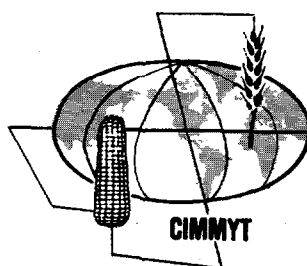


the consultative group on international agricultural research  
technical advisory committee

report of the second  
tac quinquennial review of the  
international maize and wheat  
improvement center  
(cimmyt)



tac secretariat  
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

THE CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH  
TECHNICAL ADVISORY COMMITTEE

REPORT OF THE SECOND  
TAC QUINQUENNIAL REVIEW OF THE  
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER  
(CIMMYT)

TAC SECRETARIAT  
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS  
August 1983



# CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

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From: The Secretariat

June 20, 1983

## Consultative Group Meeting

May 25-27, 1983

Paris, France

### CIMMYT EXTERNAL REVIEW (AGENDA ITEM 4) <sup>1/</sup>

"Professor John Dillon, Chairman of the External Review Panel, presented the panel's findings to the Group; Professor Camus summarized TAC's recommendations; and Dr. Virgilio Barco, Chairman of the CIMMYT Board, and Dr. Robert Havener, Director General of CIMMYT, explained certain aspects of the center's policies and activities and generally concurred with the review panel's findings. In his summary of the lengthy discussion that followed, Mr. Baum described the debate as by far the most extensive and substantive yet on an external review. High praise was due to Professor Dillon and his associates for a first-class report. The review did, in fact, as one speaker pointed out, repeat some of the conclusions of the first review, leading the Group to expect that this time the recommendations would be fully implemented by the center and by TAC. The basic point to recognize is the very high quality of CIMMYT's work and of the staff. The center can claim impressive achievements, but, these noted, the panel recommended changes to enable CIMMYT to undertake successfully the formidable tasks ahead.

The Chairman made the following points in summarizing the conclusions of the Group's discussion:

- (i) the donors strongly supported the recommendation that the scientific underpinnings of CIMMYT's research work would have to be strengthened;
- (ii) the center will also have to give greater attention to maintenance research, and to the sharing of responsibility between itself and national entities for such research;

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<sup>1/</sup> Extract from "Main Conclusions Reached and Decisions Taken"  
CGIAR Mid-Term Meeting, May 25-27, 1983, Paris, France.



- (iii) TAC recommended, and the Group supported the proposal, that CIMMYT should be moving towards a program of longer-term conservation of genetic resources; the budgetary implications of this recommendation need to be defined;
- (iv) training, though the activity most easy to cut in times of financial shortfalls, should remain high among CIMMYT's and the Group's priorities;
- (v) the Group requested CIMMYT to give more attention to communication of the results of its work; and
- (vi) the Group urged that at the conclusion of the forthcoming external reviews of ICARDA and IITA, TAC make clear recommendations as to each center's ultimate responsibilities to end the current overlap in jurisdiction between CIMMYT and the other two centers. A recommendation will be made by TAC to the Group in November on the division of responsibility between ICARDA and CIMMYT for durum wheat and barley and between CIMMYT and IITA for maize in May 1984.

The Chairman pointed out that the recommendations had resource implications. Although the review panel considered that there were areas in which CIMMYT could reduce expenditures, the scientists who had evaluated CIMMYT's work program had also indicated areas where more resources were required. However, the Chairman stated that in a situation of scarce financial resources, judgements among centers could only be made in the context of a system-wide budgetary review. The review panel had endorsed CIMMYT's "minimum/optimum" program for the future; TAC also endorsed it, though considering that the operative word should be minimum and that CIMMYT should be allowed to reach and maintain that minimum level; and the Group recognized that it is a sound program which CIMMYT should undertake to the extent that resources permit.

The review panel and TAC brought to the attention of the Group the operational difficulties and limitations on program effectiveness caused by the present lack of a clear definition of the international status of CIMMYT in Mexico, its principal host country. Mexico, although not present at the Paris meeting, is a member of the CGIAR. The Group noted the serious nature of the problem and requested the CG secretariat to provide whatever support is necessary to help CIMMYT resolve it satisfactorily. The three co-sponsors (the FAO, UNDP and World Bank) expressed their willingness to help CIMMYT and the Government of Mexico find a formula - possibly based on experience with other CGIAR centers - that would provide CIMMYT with full international status."

**CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH**  
**TECHNICAL ADVISORY COMMITTEE**

**The Chairman**

Mr. Warren C. Baum  
Chairman, CGIAR  
1818 H Street, N.W.  
Washington, D.C. 20433  
U.S.A.

18 March 1983

Dear Mr. Baum,

I have the pleasure to submit to you the report of the Second Quinquennial Review of CIMMYT which was conducted in September 1982. The Review Panel was chaired by Prof. J.L. Dillon, who presented the report to TAC at its 29th meeting in the World Bank in Washington, in the presence of Dr. R.D. Havener, Director-General of CIMMYT.

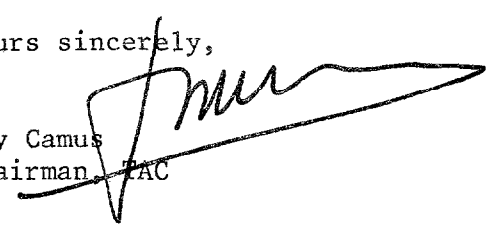
By the 30th meeting of TAC, the Centre had already responded to some of the recommendations, had considered the report and had provided the Committee with its written reactions. The Committee had the opportunity to discuss the wide range of the report's recommendations in light of the Centre's reaction. Both TAC and CIMMYT find the report highly supportive of the Centre's activities.

On the basis of its discussions, TAC prepared a commentary on its own conclusions and recommendations, taking into account that several issues are closely related to other Centres, especially ICARDA, IITA and CIAT. The Committee, therefore, wished to consider these issues in more detail at a later stage when the Quinquennial Review reports of the first two Centres are presented for discussion.

TAC recognizes the excellent quality of the report. It also strongly supports the Panel's recommendations for more resources, based on CIMMYT's achievements and work. The Committee believes, however, that the allocation of resources needs to be considered in relation to the whole System, at TAC's annual Programme and Budget reviews.

The main issues requiring discussion by the Group have been outlined in TAC's commentary, which together with the commentary of CIMMYT are attached to the Review report. The Committee would appreciate an indication of the Group's views on these.

Yours sincerely,

  
Guy Camus  
Chairman, TAC



## TAC COMMENTARY ON THE SECOND QUINQUENNIAL REVIEW OF CIMMYT

1. In transmitting the report of the Second Quinquennial Review of CIMMYT to the CGIAR, TAC wished to commend and thank Prof. J.L. Dillon and his colleagues for their thoughtful and thought-provoking report, and to note the general impression of strong support for CIMMYT that emerges from it.
2. TAC was able to discuss an earlier draft of the report with Prof. Dillon during its meeting in Washington in 1982. It appears, however, that only a few of the comments made have been considered in the final version. Unfortunately, TAC could not discuss the final draft with the Panel Chairman, but was able to discuss with the Centre Director, Dr. R.D. Havener, a CIMMYT commentary on the Quinquennial Review report and its many recommendations. Out of these discussions, the Committee has chosen to comment on a few major aspects on which it would be particularly helpful to have a discussion by the Donors.

Constitution and International Status

3. The Review report and the CIMMYT commentary make it clear that the Centre's work has for sometime been seriously hampered by its chronic lack of official international status. TAC therefore urges that the Government of Mexico, as a member of the Group, take action to resolve the matter, and that the Co-Sponsors stand ready to assist in the resolution of the issue as a matter of urgency. The later stages of this matter may have to await some revision of the formal mandate, but TAC believes this could be achieved by 1984 at the latest.

Mandate

4. The Quinquennial Review recommended, and CIMMYT endorsed its belief in, the merits of the Institute having global responsibility for germplasm development of maize and "winter" cereals (defined by CIMMYT as including both winter and spring forms of bread wheat, durum wheat, triticale and barley). At this stage, and until it has completed its review of strategic considerations, TAC considers it more appropriate not to take a final position on this recommendation and to wait for the outcome of the ICARDA and IITA Reviews. TAC however appreciates the constructive attitude of the Director-General of CIMMYT in this matter, and his suggestion that any rearrangement of the mandates for these important crops should be initiated by TAC and the CGIAR.
5. Three matters are at issue. The first is whether CIMMYT or ICARDA should have the primary (to avoid the overly ambitious term ('global')) responsibility for barley. Were it to be ICARDA, then the purpose of

CIMMYT's supplementary role, the clear definition of its geographic or agroclimatic extent, and the nature of its cooperation with ICARDA would need to be specified (or vice-versa).

6. Durum wheat constitutes the second problematic issue. CIMMYT has achieved quite remarkable improvement in the yield potential of durum wheat, especially when grown under favourable conditions. There may be advantages to be derived from research on bread wheat, durum and triticale as a group. However, TAC notes that in the developing countries the great bulk of durum wheat is produced in West Asia, the Mediterranean region and North Africa under dryland conditions which are of particular concern to ICARDA's mandate. TAC believes this matter warrants further investigation and discussion.

7. The respective roles of CIMMYT and IITA in relation to maize in West Africa (and perhaps more widely in Africa) also need reconsideration, and TAC at this stage is not ready to accept the recommendation of the Review team (p. 101), although it recognizes the strength of the arguments in favour of it.

#### The Impact of CIMMYT's Work

8. The huge and widespread impact of CIMMYT's wheat programme, and the growing impact of the maize programme as noted by the Review, must surely be gratifying and encouraging to Donors. A more recent assessment of the impact was provided by CIMMYT in Annex I of its commentary.

9. However, TAC considers that a better documented and more closely analyzed statement of the impact of these two programmes would be helpful, and that this should be continuously monitored by CIMMYT's economists in close collaboration with staff in other disciplines. Also, apart from the impact of the additional production of wheat and maize, there remains a need for a further analysis of CIMMYT's impact on national programmes, on institution-building, as well as on the building up of a network of cooperating trainees and alumni. The Review refers to cases in which there has been a decline in interactions (para. 38, p. 179), and TAC believes it could be instructive to examine the reasons behind such regression.

10. The Committee recognizes that the most effective forms of interactions with national systems will depend on the style of operation of the Centre, and that these vary greatly. TAC's central concern is that institution-building should be effective in the long-term, and not too vulnerable to short-term political and financial changes.

## Scientific Programmes

### (a) Strategy of the Wheat Programme

11. The Review generally endorses the strategy of the Wheat Programme and refers to continuing increases in yield capacity and dependability of the small grains. However, these statements are not substantiated, and independent evidence suggests that the yield potential of bread wheat, at least, may be on or nearing a plateau. If this is the case, CIMMYT should perhaps reconsider its strategy and the resources devoted to it. The point may have been reached where more resources should be devoted to supporting disciplinary work (e.g. in pathology, physiology and genetic analysis) at headquarters. CIMMYT should, therefore, publish the evidence in support of the above review statements so that independent assessments can be made.

### (b) Maize Programme Strategy

12. The review sets out (p. 87) and endorses (p. 100) the case for the strong emphasis on open pollinated varieties by the Maize Programme. TAC recognizes the appropriateness of this strategy for developing countries in which the seed industry is not well developed, but in view of the growing strength of the seed industry in many developing countries, of the substantial yield gains and of farmer interest in the use of hybrids, TAC believes that the matter merits reappraisal by the new Director of the Maize Programme. Just how far CIMMYT should go in the development of specific hybrids would of course require careful assessment.

### (c) The Maize/Wheat Balance

13. Although the leanness of the staff resources at headquarters for the small grain breeding programmes is commented on, and the undesirable degree of vulnerability of these programmes as a result (p. 56), the view is also put that the Maize Programme has received less than its share of CIMMYT resources. The CIMMYT commentary indicates several accounting procedures which led the Review team to underestimate the resources devoted to maize, which are in fact almost equal to those for the small grains. TAC also notes that the "wheat" programme includes four different crops. On the other hand, maize is grown on a significant scale (> 100 K ha) in far more countries than any other crop, and both wheat (CIMMYT sensu latu) and maize probably deserve additional resources.

### (d) Maintenance Research

14. In its commentary on the IRRI Quinquennial Review TAC emphasized to Donors that the more the yield or frequency of cropping is raised, the greater is the research effort required to defend these gains. Old problems are exacerbated and new ones are introduced. The case TAC put for rice applies just as strongly to wheat and maize. Although some of this

maintenance research can be taken over by the more advanced developing countries and some developed countries, many of the poorest cannot do so. Moreover, the economies of scale which apply to the breeding and cooperative testing of new germplasm apply as strongly to the maintenance phase as to the initial work. TAC, therefore, supports CIMMYT's plea that the Donors recognize the crucial importance, if lesser glamour, of maintenance research in defense of past gains.

(e) The Balance between Headquarters and Regional Research

15. This is an important and complex issue which is difficult for both TAC and a review team to assess adequately. TAC has, for several years, expressed to CIMMYT the view that its headquarters research is minimal and vulnerable and needs strengthening to ensure long-term progress on CIMMYT's objectives. The institute, on the other hand, has emphasized its belief in the great effectiveness of its regional programmes, and its determination to maintain and enhance them.

16. The Review team considers the criteria for, and deployment of, regional programmes (pp. 151 - 156), their balance and interaction with headquarters, and their composition. TAC agrees with the recommendation that greater use should be made of agro-climatic information in setting up regional programmes (p. 162), and that more selective deployment may be desirable. TAC would add that it hopes CIMMYT will make more use in future of expertise within national programmes, e.g. in the area of economics, in order to streamline its regional programmes and give the countries of each region a greater role in them.

17. CIMMYT's regional programmes are an important innovation, and some have had considerable impact on the regions they are supposed to serve. Nevertheless some members of TAC wish to call the attention of the Centre for the need to further strengthen specific regional programmes.

18. Concerning the staffing balance between headquarters and regional activities, TAC intends to examine this issue on the occasion of its annual examination of P&Bs.

(f) Genetic Resources

19. CIMMYT has, in the past, defined its responsibility for germplasm conservation, evaluation and distribution of its mandate crops as limited to working collections. Partly, this was in recognition of existing major base collections elsewhere, and partly because it assigned higher priority to other activities.

20. The Review urges CIMMYT to maintain and extend its present activities, and suggests that IBPGR and other international institutions concerned should consult with it to refine their respective responsibilities (p. 192). The groundwork has already been laid by the joint IBPGR-CIMMYT Committee on maize and the IBPGR-CIMMYT-ICARDA Committee on wheat.

21 TAC strongly endorses this recommendation, and would add the request that an estimate of the additional capital and running costs be made, so that these can be considered separately from CIMMYT's present budget.

(g) Economics Programme

22. TAC has already suggested that the Centre's economists could play a valuable role in the system by continuing to monitor the impact of CIMMYT's work, not only on cereal production but also on the national systems. The Committee strongly supports the review team's recommendation (p. 123) that the Economics Programme should be able to play a greater role in helping to generate and analyze data to define the Centre's priorities, to which TAC would add also the identification of constraints. This will require wider interaction between the economists and the biologists than has occurred in the past, and the time seems opportune for such a change.

23. TAC views the above roles for the Centre economists as being of much greater importance than the pursuit of the macro-studies recommended by the Review team (E 53). Indeed, the Committee sees these as the province of IFPRI. However, TAC notes the informal contacts between CIMMYT and IFPRI and encourages more formal discussion and collaboration on these matters along the lines suggested.

(h) Farming Systems

24. CIMMYT has no formal farming systems programme and no wish to develop one. On the other hand, its regional agronomists and economists play a significant role in on-farm research in many developing countries. TAC believes this is an appropriate strategy for the Centre, but hopes that some comparative assessment of the impact of this approach can be made.

25. CIMMYT already has an effective symbiosis with CIAT and IRRI on farming systems research, and TAC hopes that similarly productive arrangements will develop with ICARDA, ICRISAT and IITA.

Training

26. The Review team recommends that CIMMYT should appoint a Director of Training. CIMMYT rejects this recommendation, and TAC sympathizes with and accepts its reasons, given the present structure of its two commodities and Economics Programmes.

27. However, the Committee believes CIMMYT's overall approach to training should be re-examined with a view to redefining its objectives, style, levels and variety, and was pleased to hear that such a review is



already being planned. One result could well be the recognition of the need for, if not a Director, at least a much stronger coordination of the Centre's training programmes.

#### Future Plans

28. TAC agrees with the Quinquennial Review Panel in broadly endorsing the Centre's 'minimum-optimum' model. However, it considers that the operative word in this rather odd name is minimum, and that the Centre must be allowed to reach and maintain that minimum level. The structure of the model is broadly consistent with the comments TAC has made above.

29. TAC notes the list of additional appointments proposed by the Review team (p. 200), but would prefer to consider the matter during the usual budget review process when these items will be discussed in the light of the requirements of the other Centres.

30. However, the Committee's earlier comments make it clear that CIMMYT merits and needs substantial additional resources in several areas. TAC will address these issues in the annual budgetary review process.

COMMENTS BY CIMMYT TO THE CGIAR ON THE REPORT OF THE SECOND  
EXTERNAL REVIEW OF THE CENTER.

1. INTRODUCTION

1.1 This paper represents the distillation of the product of an extended process of reflection and reaction by the Directing Staff of CIMMYT and the Board of Trustees. The full Board and the Directing Staff had an opportunity for interaction with the Review Panel as it was formulating its recommendations in September 1982. CIMMYT also at that time submitted to the panel detailed factual comment on the draft report, but this failed to catch up with the editing process. When the final version of the report was received later in 1982, considered comments by the Directing Staff were collated and presented to a six member committee of the Board, specially convened in January 1983, which included the Chairman of the Board, the Chairmen of the Executive and Program Committees and the Director General. The advice of the Vice-chairman, the Director General of INIA in Mexico, was also available at that time. This committee prepared for the TAC a full commentary on the report, consisting of an analysis of the principal issues as seen by CIMMYT, supported by an annex reviewing all recommendations in detail and an annex up-dating the analysis of the impact of CIMMYT programs. These documents were available to the TAC when it discussed the report with CIMMYT representatives in Rome in March 1983 and are reflected in the TAC report to the Group. Some elements are repeated here after review by

the Program Committee and the full Board at CIMMYT Headquarters in March 1983. The present document, therefore, is based on complete involvement by the Board of Trustees in deep and responsible consideration of the recommendations of the external review. Where subsequently statements are made such as "CIMMYT agrees" or "CIMMYT believes" they carry this full degree of authority.

1.2 At the outset CIMMYT wishes to express its gratitude to the Review Panel for its diligent and sympathetic investigation and for its constructive and encouraging report. It also appreciates the commentary by the TAC on the issues singled out by them as major aspects deserving consideration by the Group. It agrees with these comments. The views expressed in these reports will be of continuing value to the Board and Management of CIMMYT in developing plans for the years ahead.

## 2. CONSTITUTIONAL ISSUES

2.1 As is stated in the report, the legal basis for CIMMYT's establishment in Mexico was an Agreement dated 12 April 1966 between representatives of the Government of Mexico and the Rockefeller Foundation to constitute CIMMYT as a "Civil Partnership" or not-for-profit corporation under the laws of Mexico. There is nothing in this document which assigns a mandate to CIMMYT, in the sense of a grant or entrustment by an authority external to CIMMYT of defined

responsibilities which delimit the scope of CIMMYT's objectives, purposes and operations. The parties to the Agreement jointly declared that the purpose of CIMMYT was "to promote and carry out, nationally and internationally, programs to improve in all its aspects maize and wheat production and if advisable (presumably in the opinion of its governing body) the production of sorghum, rice, and other food crops, in order to obtain greater unit yields and better production and quality of these crops". A listing followed of activities to be undertaken in pursuit of this objective. It could be said that CIMMYT has never been given a mandate. By decision of its governing body, it has limited its work on crops to maize, bread wheat, durum wheat, barley and triticale.

2.2 In the case of IARCs established since 1971, the charter or articles of association incorporate a statement of objectives, which are sometimes put in a geographical or ecological context. These "constitutions" have been submitted to and deemed to have been endorsed by the CGIAR, a process which endowed the statement of objectives with the character of a mandate. The interpretation and discharge of this mandate has subsequently been the responsibility of the governing body of the center.

2.3 The constitutions, and in some cases related documents, of IARCs seek to establish several separable elements:

- a) The status, international and legal, of the institution;
- b) Location of its Headquarters;
- c) Its objectives and purposes;
- d) The area of geographical concentration, if applicable;
- e) Its machinery of government;
- f) Action on its dissolution;
- g) Relations with the host government (sometimes a separate "Headquarters Agreement")

(c) and (d) above constitute "The Mandate". CIMMYT's present arrangements are to varying degrees deficient in all but (b) and (e).

### 3. CIMMYT'S INTERNATIONAL STATUS

3.1 CIMMYT believes that recognition of its international status and improved facilities for its operations in Mexico are the most pressing requirement. This is recognised by the panel (report B19 thru 21) and also by the TAC. Protracted if sporadic discussions have taken place with successive governments in Mexico but have up to now been inconclusive. CIMMYT believes that these issues could be addressed in advance and separately from a redefinition of the mandate and is anxiously seeking the best avenue of approach to this serious problem. It welcomes the observations on this subject in the report and the recommendations of the TAC.

#### 4. CIMMYT's OBJECTIVES AND PURPOSES

4.1 Also important from the point of view of CIMMYT's global action is a redefinition of CIMMYT's purposes and objectives, which might include guidelines on its relations with other IARCs and regional and national institutions. If such a redefinition were submitted for appraisal and ratification by TAC or the CGIAR, or both in sequence, it could constitute a mandate. The Board of Trustees will be giving attention to this possibility and to the thought that such a document might include an assertion of CIMMYT's status as an international organisation (which is implicit in the title it has had from the start) and a reformulation of its mode of governance.

4.2 CIMMYT considers however that such action would not by itself, even if accompanied by similar and congruent action by other IARCs with which CIMMYT has cooperative relationships, solve the problems, current and prospective, evoked in para. H59 of the report. It might in fact only shift the frontiers of dispute and exacerbate the probability of a legalistic and jurisdictional approach to instances of friction. This sort of problem cannot be effectively addressed by a single IARC on its own or, where apparent principles are invoked, settled by inter-center conversations. Some arbiter is needed with an understanding of the policies and capacities of the parties involved and

the needs of the developing countries for service from the CGIAR system. The impending reports of external reviews of ICARDA and IITA will further illuminate the areas in which some objective solution should be sought for problems of imperfect collaboration between CIMMYT and these centers. CIMMYT believes that there is considerable merit in continuing to take primary responsibility for germplasm development of maize and winter cereals<sup>1/</sup>. This role is consistent with the recommendations in the report regarding responsibility for these crops and the preliminary observations of the TAC. CIMMYT's resources would be available to any national program, provided such service is compatible with its approved program and existing capacity.

4.3 In this context CIMMYT also agrees with the panel and the TAC that the preservation of germplasm and the regeneration and evaluation of material is important. CIMMYT fully endorses dialogue at the level of the CGIAR system to determine how these responsibilities could best be assigned and financed.

## 5. IMPACT OF CIMMYT PROGRAMS

5.1 CIMMYT welcomes the reference by TAC in its commentary to CIMMYT's up-date of its evaluation of impact. It also notes the TAC recommendation for continuing and more

<sup>1/</sup> For CIMMYT's purposes winter cereals include both winter and spring forms of bread wheat, durum wheat, barley and triticale.

intensive study of this aspect. CIMMYT agrees and is anxious to learn of the evolving plans for a system-wide study of impact in order that it may harmonize its own actions with this wider program.

## 6. SCIENTIFIC PROGRAMS

6.1 In Chapters C, D and E the report reviews the relevance, scope and objectives of the scientific programs, especially since the last quinquennial review, and comments favourably on the significant progress made in yield potential, and dependability, both in winter cereals and maize. The report also highlights the advances made in increasing resistance to pests and pathogens and the increasing focus on developing added tolerance to other environmental stresses (temperature, moisture and salinity, etc).

6.2 The growing impact of the maize program has been noted in the report and in all programs there has been a greater and more effective input of agronomy and on-farm research. The growing strength of the economics program and its development of on-farm research methodology and identification of constraints has assisted materially in the adaptation of appropriate technologies, especially for the small farmer.



6.3 The review panel fully endorsed CIMMYT's continued involvement in germplasm conservation for the major crops, despite the problems inherent in funding this activity. There was also strong support for CIMMYT's vital role in the development and distribution of advanced germplasm and populations to national programs in developing countries. Some rationalization of the diversity and growing size of this activity is urgent, as indicated by the review. Coupled with this activity is the urgent task of preserving the gains achieved in yield, quality and adaptation by protection from the steady erosion caused by pests and pathogens. The need to continue developing more durable resistance in CIMMYT's advanced breeding material is of high priority. CIMMYT welcomes the comments by the TAC on the importance of maintenance research.

6.4 The review recommended strengthening the scientific support for CIMMYT's major breeding programs. The center is moving steadily to achieve this through appointments and through collaborative research with advanced research institutions. This is being done without sacrificing the highly successful applied breeding focus that has been the basis of CIMMYT's success.

6.5 The progressive move to regionalize the center's off-campus activities has been limited by staffing constraints. The review team's plea for greater selectivity

in the deployment of regional activities will be reviewed, as more detailed agro-climatological and socio-economic information on the regions is obtained.

6.6 The Center notes the review panel's criticisms of certain aspects of training. There is undoubtedly scope for improvement in this area and an in-house review on training, which had been initiated prior to the review, will take account of the suggestions in the report. Coordination of the training program, provision of more adequate training facilities and improvement in the level and content of the training courses are under serious discussion. Currently, CIMMYT is not convinced of the need for a post of Director of Training and notes the observations of the TAC in this regard.

6.7 CIMMYT, like most applied research institutions, has a perennial problem in devoting enough time to scholarly publications. However, steps are being taken to increase the published output of the Center. There is recognition of the need to document the many novel breeding approaches used by CIMMYT in its maize and cereal programs. Also the analysis of the considerable store of unique data from the international trials conducted over many years is underway, utilizing the new computer facilities recently commissioned in the center. Collaborative Research Projects will also facilitate the publication of manuscripts under joint

authorships by CIMMYT staff and scientists from collaborating institutions. However, CIMMYT believes that in its communication with the world scientific community it must continue to use additional channels which are more direct, selective and effective than publication in scientific journals.

## 7. PARTICIPATION OF DEVELOPING COUNTRIES IN DETERMINING PRIORITIES IN CIMMYT PROGRAMS AND THE RESEARCH STRATEGIES TO BE ADOPTED.

7.1 The Review Panel recommends (para. G-44) that CIMMYT develops effective cooperative mechanisms to facilitate inputs from cooperating National Programs into the determination of priorities and research strategies. It is the policy of CIMMYT to base the evolution and conduct of its programs on the perceived and expressed needs in relation to its crops of the developing countries which it serves. The mechanisms for ascertaining these needs and continuously updating understanding of them are still imperfect. CIMMYT seeks to improve these consultative mechanisms but some of them are already reasonably well developed. They include:

- 1) Extensive travel/consultation visits made by all CIMMYT senior headquarters and regional staff.
- 2) Visits by National Program leaders and staff to CIMMYT throughout the year and particularly during presentation weeks. In addition, almost 3,000 visiting scientists and trainees have spent time in CIMMYT, Mexico. This fraternity provides one of the most effective

methods for providing information on the current needs of national programs.

- 3) CIMMYT has been officially represented at all meetings of the International Federation of Agricultural Research Directors (IFARD), which is the organization that officially represents National Research Program Leaders in Asia, Africa and Latin America.
- 4) Over 50% of the members of the Board of Trustees are from developing countries. In addition, regular meetings of the CGIAR, planning meetings at CIMMYT HQ, regional meetings, and national workshops provide many opportunities for discussions with National Program representatives.

## 8. CIMMYT'S MEDIUM TERM PLAN

8.1 The panel was presented by the Director-General with a plan for the next few years to use expected resources in a way consistent with longer-range objectives (CIMMYT Looks Ahead: 1980) but accepting a slow-down in the approach to these goals. This has acquired the odd name of the "minimum/optimum" model, an apparent contradiction in terms, which invokes the perception of a minimum scale of function to keep CIMMYT on course towards its declared objectives, combined with the best application of expected resources to this purpose. Henceforward, in this paper, it will be referred to as the "model".

8.2 The report endorses this perception of the possible scale of effort and this endorsement is supported by the TAC. But the Pnael suggests several shifts in the application of resources (shifts within the "model" would not of course by themselves provide resources adequate to implement all the recommendations of the Panel). These recommendations include some on which CIMMYT feels a degree of reservation.

8.3 These reservations have been fully presented to the TAC. It would not be profitable to present them here, since CIMMYT agrees with the TAC that such detailed shifts of emphasis within a given volume of resources are best considered during the preparation of annual and biennial program and budget exercises. This has been done in relation to the preparation of the 1984 Program and Budget proposal and will be done in subsequent years. However, CIMMYT would like to make one comment on the suggestion in the Review Panel report that undue emphasis has been given to wheat as opposed to maize, given that maize has gained momentum which should be re-inforced and an imbalance should be corrected. This impression was based on a misleading presentation of the data initially at the disposal of the panel and the TAC has recognized that in fact currently maize has received proportionately more attention and that the balance between winter grains and maize is approximately an equilibrium. But maize will not be neglected.

## 9. THE LONG-TERM PLAN

9.1 CIMMYT welcomes and is encouraged by the endorsement in the report of the targets and indicative lines of advance in its longer-term plan. It is pleased to note that the panel did not favour the radical options for changing the character and role of CIMMYT referred to in the concluding paragraphs of the report. CIMMYT also welcomes the advocacy by the TAC of CIMMYT's justified need for enhanced resources and hopes that the international development assistance community will respond to these calls for adequate support to enable CIMMYT confidently to pursue its well-charted path towards the alleviation of hunger in the disadvantaged areas of the world.

5/IV/83



## ANNEX I.

Impact of CIMMYT Germplasm in the 1970s

Over the last decade, the highest cereal production growth rates in the developing world have been achieved in maize and wheat, with both crops registering gains ahead of population growth. Much of this performance is due to continuing strong production gains made in Asia.

Today, at least 35 million hectares, equivalent to 35% of the developing country wheat area are planted to improved wheat varieties that carry CIMMYT-developed germplasm in their pedigrees. Our conservative estimate of the yield contribution made by these improved varieties alone to increased developing country production is 7 million tons, worth US\$1.2 billion this year. This is sufficient to provide 50 million people in the developing world with 65 percent of their annual caloric consumption.

While the impact of improved maize varieties is only beginning to show up in national production figures, we estimate that five million hectares in the developing world are now planted to varieties and hybrids derived from CIMMYT germplasm. The yield contribution made by these improved maize materials alone is conservatively adding at least 1 million tons annually, worth \$US150 million at current maize prices.



### Wheat Production and Consumption Trends

Some 27 developing countries cultivate over 100,000 hectares of wheat each year. The impressive production gains made during the 1960s (i.e. 2.3% increase in yield and 4.4% increase in production) in developing country wheat production were even surpassed during the 1970s. Spurred by a 3.4 percent per year increase in average yield levels, developing country production has averaged a 4.8 percent per annum gain during the 1970s.

The high production growth rates achieved in China, India, and Pakistan in Asia, and by Turkey in the Middle East, explain the high growth rates achieved in these regions during the 1970s. Wheat production increases in Latin America, despite the improving performances in Argentina and Mexico, did not keep up with the regional growth rate in population. Africa, with only about 5 million hectares of wheat in cultivation, experienced a slight decline in production during the 1970s.

To date, most of the benefits of improved wheat germplasm have accrued geographically to the major producing countries and, biologically, to the more favored environments in terms of soils and moisture availability. Although CIMMYT's widely adapted high-yielding cultivars have conclusively shown that they generally perform as well as, or better than, traditional varieties in the more

marginal environments, fewer benefits through the use of improved technology have occurred in these resource-poor areas to date.

#### Maize Production and Consumption Trends

The production story in maize is also growing in significance. Some 57 developing countries produce maize on more than 100,000 hectares. Although aggregate maize production increased slightly faster than population growth rate during the 1960s, this increase was largely due to substantial area expansions under the crop. Yields were improved at an average annual rate of only 1.3 percent, approximately half the rate achieved in wheat and rice.

A totally different and exciting scenario is now becoming apparent. Over the last five years, developing country maize production was spurred by a 2.6 percent per annum increase in yield levels, twice the rate of the 1960s. We believe that this change signals a major technological turning point in developing country maize production.

The increases in maize productivity in developing countries during the 1970s have not been uniform, and were highly influenced by the performance in Asia. The very strong gains shown for Asia are the result of the production increases achieved in China and a handful of other countries.

In Latin America, improved yield performances were registered in the major producing countries as well as among some of the smaller producers. While average yields increased at 2.5 percent per year, a slight decline occurred in total areas.

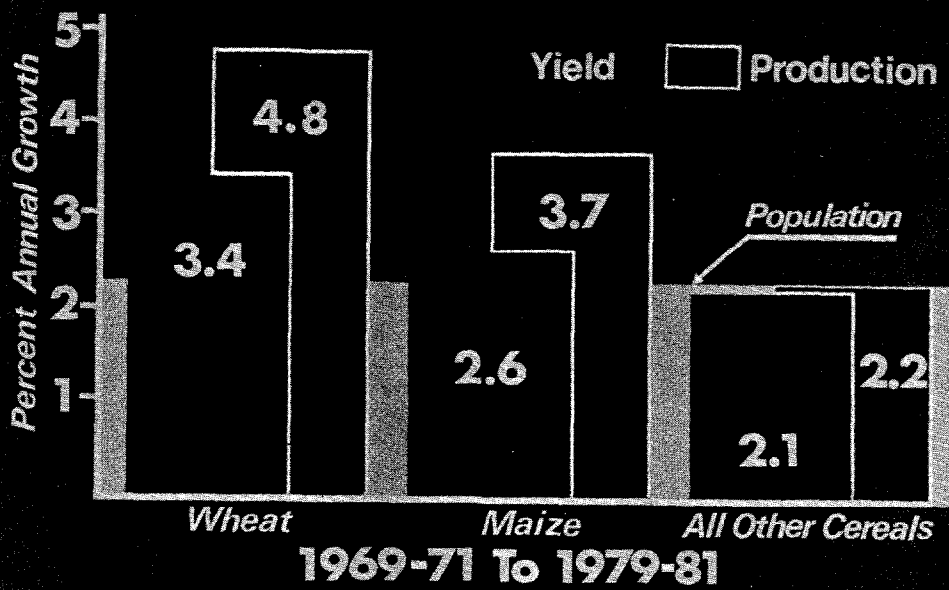
Maize production expanded more slowly in the Middle East during the last decade, and the region is becoming a major maize importer. Although most maize is produced under irrigated conditions, yields only increased at 1.2 percent per annum.

However, the area of greatest concern is sub-Saharan Africa, which achieved less than a one percent gain in production during the 1970s and no increase in yield levels. Only a few countries posted yield increases above population growth rates.

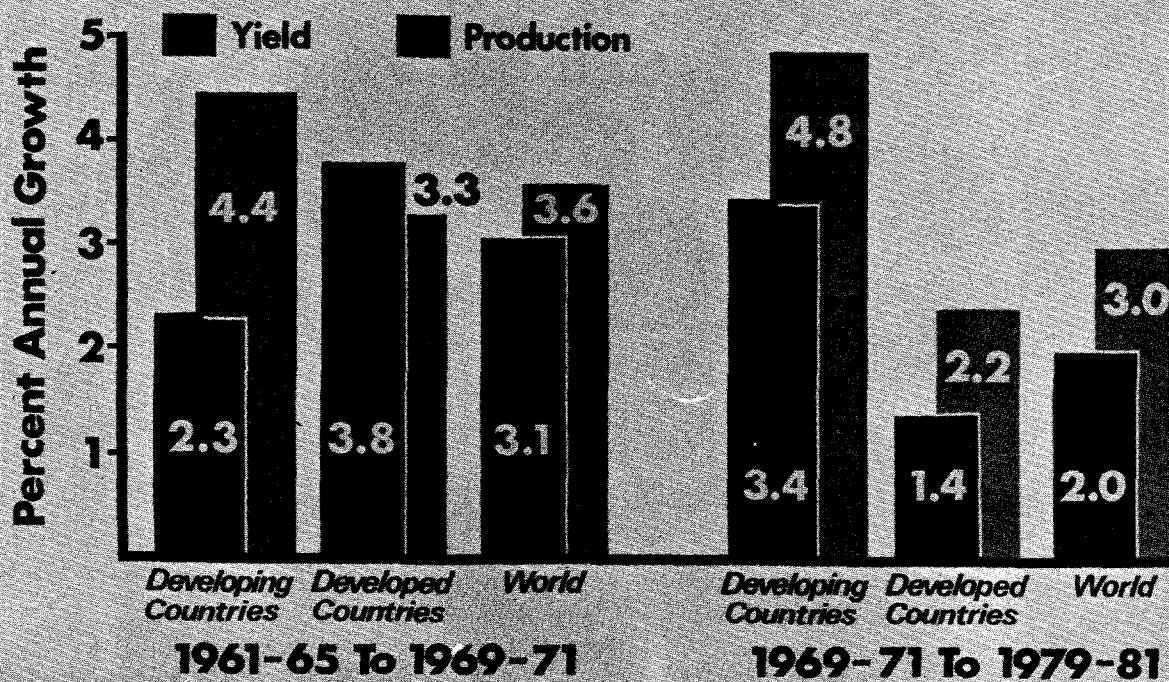
Overall therefore, in the 1970s there have been increases in both the acreages of wheat and maize, based on CIMMYT germplasm, planted by the developing countries. Concurrently there have been significant increases in average yields and a corresponding increase in production. Graphics illustrative of this analysis are attached.

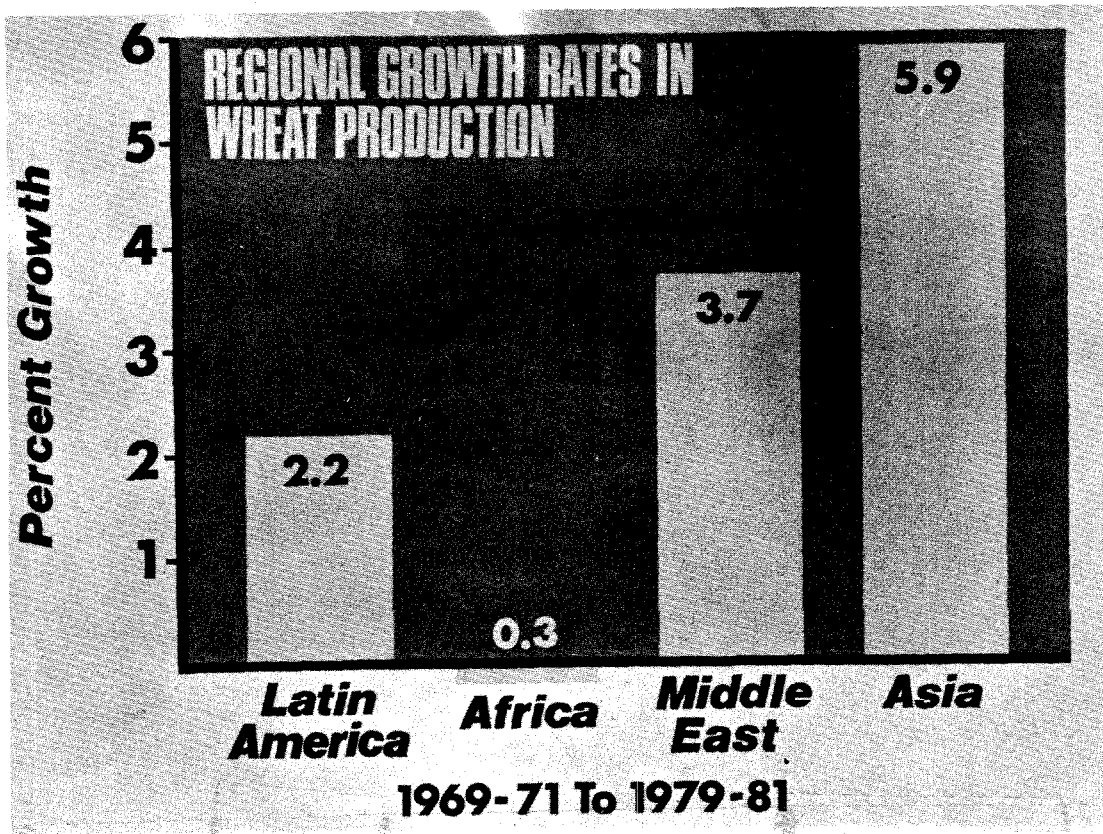
## ATTACHMENT

## GROWTH RATES OF CEREAL YIELDS AND PRODUCTION IN DEVELOPING COUNTRIES

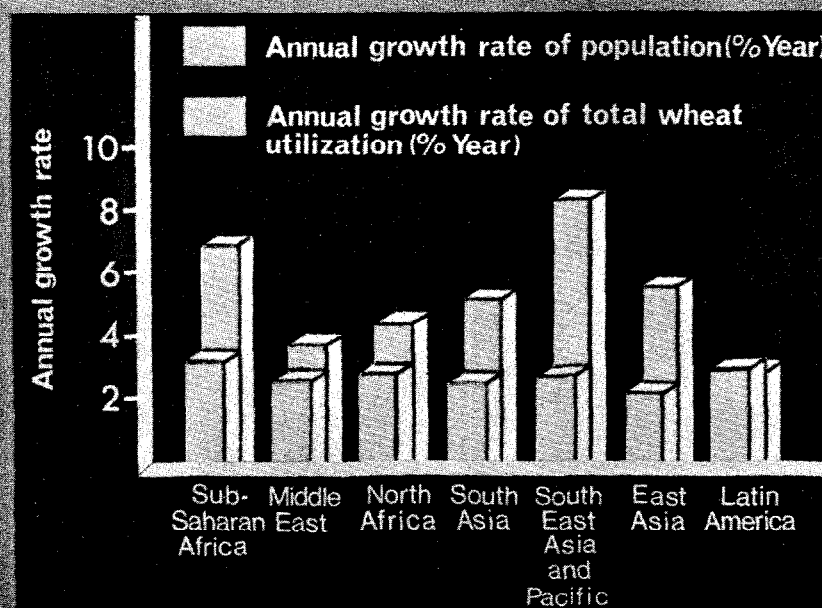


## GROWTH RATES OF WHEAT YIELDS AND PRODUCTION

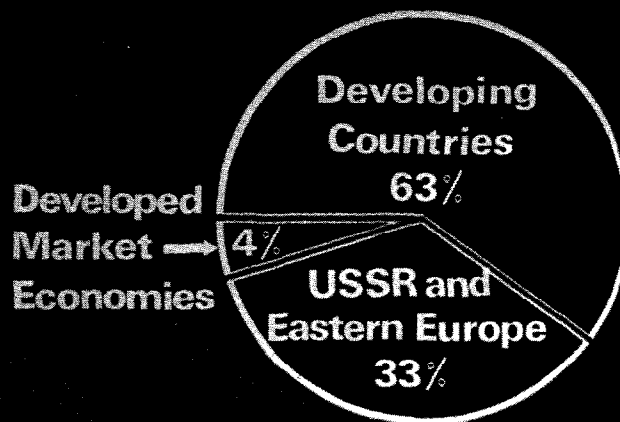




**REGIONAL GROWTH RATES OF TOTAL WHEAT UTILIZATION, COMPARED TO POPULATION, 1961-65 TO 1977-79.**



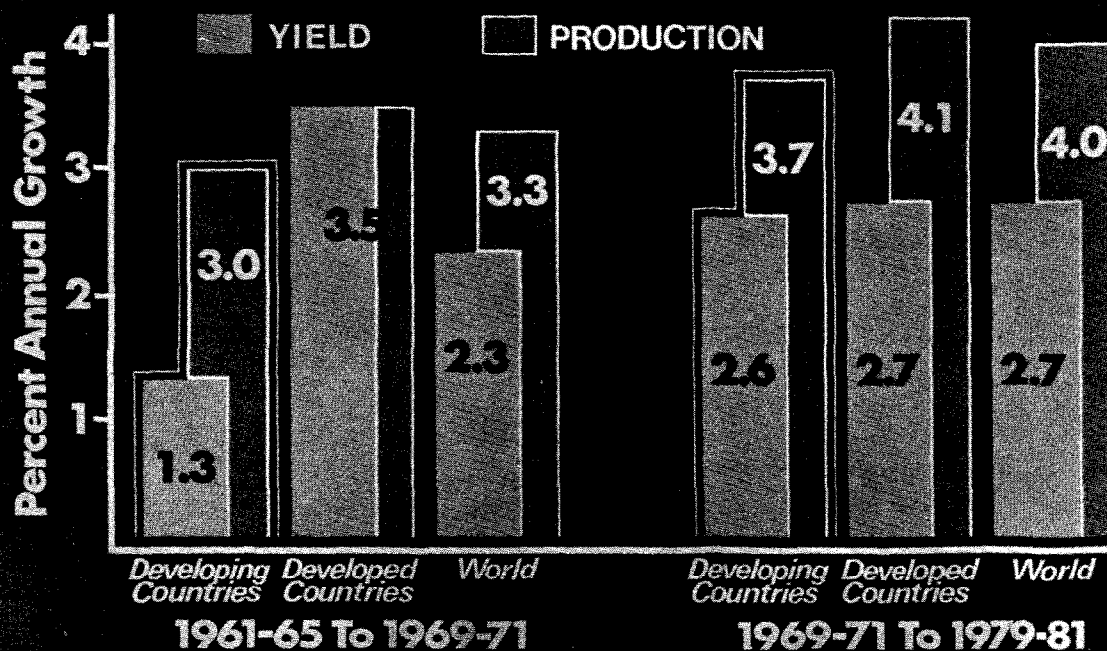
# DESTINATION OF INCREASES IN WHEAT IMPORTS, 1970 TO 1980



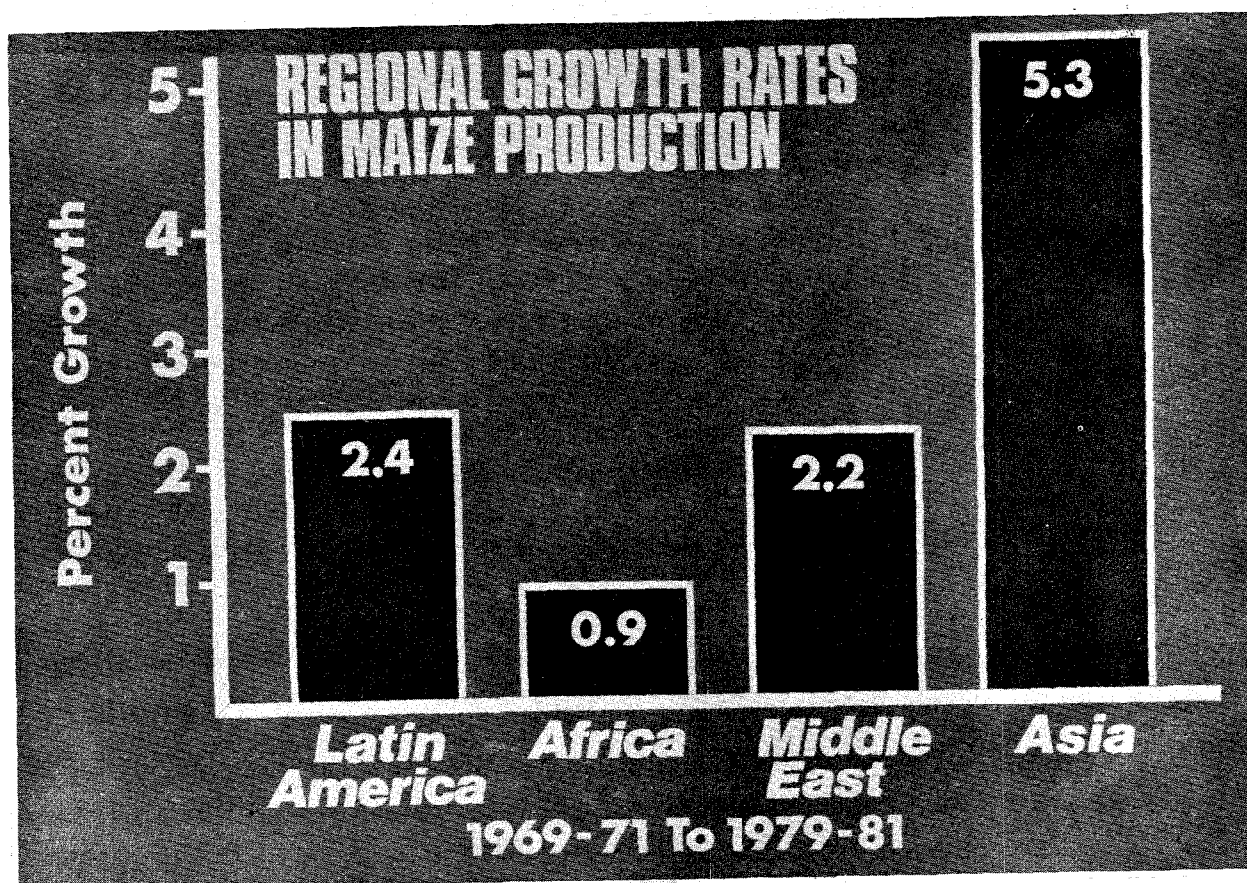
## Wheat Trade

1970	Increase	1980
55 Million Tons	44 Million Tons	99 Million Tons

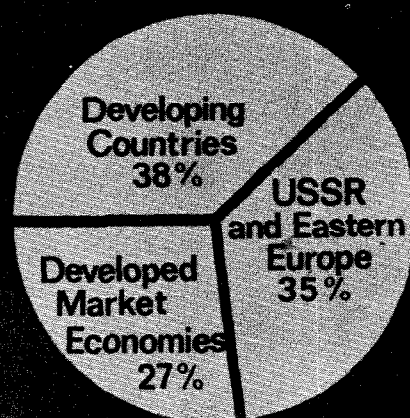
# GROWTH RATES OF MAIZE YIELDS AND PRODUCTION







## DESTINATION OF INCREASES IN MAIZE IMPORTS, 1970 TO 1980

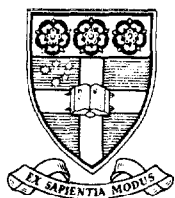


Maize Trade

**1970**  
**29 Million Tons**

**Increase**  
**51 Million Tons**

**1980**  
**80 Million Tons**



DEPARTMENT OF AGRICULTURAL ECONOMICS AND BUSINESS MANAGEMENT

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16th December, 1982

Professor Guy Camus,  
Chairman, TAC,  
C/- World Bank,  
66 Avenue d'Iéna,  
75016 PARIS, France.

Dear Professor Camus,

CIMMYT's Second QQR

On behalf of the Review Panel, I forward herewith the "Report of the Second TAC Quinquennial Review of the International Maize and Wheat Improvement Center (CIMMYT)". The Panel's work was guided by the Terms of Reference and the additional specific questions referred to the Panel by TAC.

The report has been drafted with several audiences in mind: donors, policy makers and Trustees may be particularly interested in the mandate chapter B, assessment chapter H and long-term plan chapter I; TAC members and CIMMYT staff in chapters C, D, E, F and G on the Center's programs; and those in a great hurry can use the Executive Summary we have provided at the start of the Report.

As implied by the Terms of Reference, the review was of CIMMYT per se and not of CIMMYT in relation to the total CGIAR System. Necessarily, however, the Panel encountered some questions of a System-wide nature whose resolution, I feel, will only occur in the context of a review, rationalization and perhaps reorganization of mandates. These possibilities are referred to briefly in the Report.

Likewise, though it was not specifically required to do so by its Terms of Reference, the Panel recognized the reality of likely financing to the System over the next few years. Even so, the Panel - recognizing the merit and the benefits of CIMMYT's work - was strongly of the view that the Centre justifiably requires some additional resource. Indeed, it must be emphasized that CIMMYT's task is far from done and in fact, in the face of the continuing pressures towards genetic obsolescence from diseases and pests, will never be done.

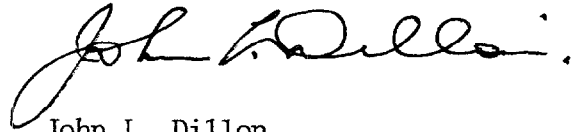
All members of the Panel were honoured to participate in its work and trust the Report will be useful to TAC, CIMMYT, current and potential donors and the CGIAR system as a whole. Certainly the Panel was a very happy one and worked most harmoniously. It had no difficulty in achieving unanimity on the Report. All this owes a great deal to the fullest of cooperation given by CIMMYT and its cooperators, and to the tremendous service given by Mr. Philippe Mahler, as Secretary to the Panel, and his assistant, Ms. Marioara Lantini.

.... /2



In conclusion, let me record my personal thanks to the members of the Panel. They worked hard and well.

Yours sincerely,

A handwritten signature in cursive script, appearing to read "John L. Dillon".

John L. Dillon,  
Chairman,  
CIMMYT QQR.

Encl.

THE CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH  
TECHNICAL ADVISORY COMMITTEE

REPORT OF THE SECOND  
TAC QUINQUENNIAL REVIEW OF THE  
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER  
(CIMMYT)

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TAC SECRETARIAT  
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS  
March 1983



TABLE OF CONTENTS

	<u>Page</u>
EXECUTIVE SUMMARY	xlvii
1. Overview Assessment	xlvii
2. The Review	xlviii
3. The Report	xlix
4. The Mandate and Its Interpretation	xlix
5. The Main Results of the Past Quinquennium	xlix
6. CIMMYT's Impact	l
7. Follow-up of the First Quinquennial Review	li
8. Future Strategies and Plans and Related Requirements	li
9. Future Resource Requirements and Allocation	lii
10. Other Recommendations	liv
11. Conclusions	liv
 CHAPTER A - INTRODUCTION	 1
1. Introduction	1
2. Terms of Reference	2
3. The Review Procedure	4
4. The Report	6
 CHAPTER B - MANDATE, STRATEGY, OVERALL ORGANIZATION AND MANAGEMENT	 8
1. Introduction	8
2. Mandate of CIMMYT and Its Interpretation	9
3. Strategy	13
4. Legal Status of CIMMYT in Mexico	16
5. Organization, Administration and Management	17
6. Personnel	19
6.1. General Comments on Administration of Personnel	21
6.2. Recruitment of Personnel	21
6.3. Utilization of Postdoctoral Fellows	22
6.4. Professional Development of Staff	22
7. Financial Resources and Management of Funds	22
7.1. Budget	25
7.2. Allocation of Funds	27
7.3. Priority Setting, Program Formulation and Resource Allocation	27
7.4. Auditing	32

	<u>Page</u>
CHAPTER C - WHEAT PROGRAM	36
1. Historical Background	36
2. General Objectives	39
3. General Structure and Content of the Program	40
3.1. Germplasm Bank	40
3.2. Wide Crosses	41
3.3. Germplasm Development	42
3.4. Breeding Programs	43
3.5. International Testing	47
3.6. Regional Programs and Bilateral Programs	49
3.7. Maintenance of Recommended Varieties and Seed Production	52
3.8. Pathology	52
3.9. Milling and Baking Quality	54
3.10. Agronomy	54
3.11. Training	55
3.12. Communications	56
4. Means and Facilities	56
4.1. Staff and Other Personnel	56
4.2. Land and Equipment	57
4.3. Budget	57
5. Achievements	57
6. Constraints	59
7. Future Plans	59
7.1. Wide Crosses	60
7.2. Germplasm Bank	61
7.3. Germplasm Development	61
7.4. Breeding Programs	61
7.5. International Testing	62
7.6. Regional Programs and Bilateral Programs	62
7.7. Pathology	63
7.8. Agronomy	63
7.9. Training	63
8. Assessment and Recommendations	63
8.1. Germplasm Bank	63
8.2. Wide Crosses	64
8.3. Germplasm Development	64
8.4. Breeding Programs	65
8.5. International Testing	68
8.6. Regional Programs and Bilateral Programs	68
8.7. Maintenance of Recommended Varieties and Seed Production	69
8.8. Pathology	69

8.9. Milling and Baking Quality	69
8.10. Agronomy	70
8.11. Training	71
8.12. Communications	73
 CHAPTER D - MAIZE PROGRAM	 75
1. History and Background	75
2. General Objectives	76
3. Program Structure and Procedures	77
3.1. Germplasm Development and Population Improvement	77
3.1.1. Germplasm Bank and Wide-Cross Unit	77
3.1.2. Gene Pool Improvement and Characterization	79
3.1.3. Population Improvement and International Trials	80
3.2. Selection Criteria and Procedures	81
3.2.1. Nutritional Quality Improvement	81
3.2.2. Resistance to Diseases	83
3.2.3. Resistance to Insects	84
3.2.4. Crop Physiology	84
3.3. Associated National Program Activities	86
3.3.1. Contribution to Population Improvement by National Programs	86
3.3.2. Development and Release of Varieties and Hybrids	86
3.3.3. Seed Production	88
3.4. Regional, Bilateral and Collaborative Projects	88
3.4.1. Breeding	88
3.4.2. Agronomy, On-Farm Research and Training	89
3.5. Training and Agronomy by CIMMYT in Mexico	91
3.6. Communications	92
4. Staffing, Facilities and Budget	93
5. Accomplishments of the Maize Program	94
6. Future Plans and Constraints	96
6.1. Maize Germplasm Bank	96
6.2. Wide-Cross Unit	96
6.3. Germplasm Development	97
6.4. Population Improvement	97
6.5. International Testing	98
6.6. Nutritional Quality Improvement	98
6.7. Disease Resistance	98
6.8. Insect Resistance	98
6.9. Crop Physiology	99
6.10. Regional Maize Programs	99
6.11. Bilateral National Maize Programs	99
6.12. Maize Training Programs	99

7.	Assessment and Recommendations	100
7.1.	General Comments	100
7.2.	Assessment and Recommendations for the Sub-Programs	103
7.2.1.	Germplasm Bank	103
7.2.2.	Wide-Cross Unit	104
7.2.3.	Germplasm Development and Population Improvement	104
7.2.4.	International Testing	104
7.2.5.	Nutritional Quality Improvement	105
7.2.6.	Disease and Insect Resistance	105
7.2.7.	Crop Physiology	106
7.2.8.	Regional Maize Programs	106
7.2.9.	Bilateral National Maize Programs	106
7.2.10.	Maize Training Programs	107
7.2.11.	Communications Unit	107
	CHAPTER E - ECONOMICS PROGRAM	108
1.	Background	108
2.	General Objective	109
3.	Activities	109
4.	Staff and Facilities	111
5.	Achievements	112
5.1.	Farm-Level Research Procedures	112
5.2.	Training	113
5.3.	Data Compilation and Analysis	115
5.4.	Regional Programs	116
5.5.	Seminars for Policy Makers	118
6.	Constraints and Other Considerations	118
7.	Future Plans	119
8.	Assessment and Recommendations	121
8.1.	Staffing	121
8.2.	Characterization of Maize and Wheat Production Areas	122
8.3.	Maize and Wheat Facts and Trends and Their Analysis	122
8.4.	Contribution to CIMMYT's Choice of Priorities	123
8.5.	Monitoring of CIMMYT's Impact	124
8.6.	Training	124
8.7.	Inter-Program Collaboration	124
8.8.	Institutionalization of On-Farm Research	126
8.9.	Implementation of On-Farm Research	128
8.10.	Policy Implications from On-Farm Research	129

CHAPTER F - SUPPORTIVE DISCIPLINARY RESEARCH AND SERVICES	130
1. Introduction	130
2. Supportive Disciplinary Research at Headquarters and Collaborative Research	130
2.1. Supportive Disciplinary Research at Headquarters	130
2.2. Collaborative Research	131
2.3. Assessment and Recommendations	133
3. Laboratory Services	135
3.1. Background	135
3.2. General Objectives	135
3.3. Organization and Procedures	135
3.4. Staffing, Equipment and Facilities	136
3.5. Accomplishments	136
3.6. Assessment and Recommendations	138
4. Data Processing	139
4.1. Background	139
4.2. General Objectives	139
4.3. Organization and Procedures	139
4.4. Staffing and Equipment	140
4.5. Accomplishments	140
4.6. Future Plans	140
4.7. Assessment and Recommendations	141
5. Publications	142
5.1. Background and Objectives	142
5.2. Organization and Procedures	142
5.3. Staffing and Facilities	143
5.4. Accomplishments	143
5.5. Future Plans and Constraints	143
5.6. Assessment and Recommendations	144
6. Library Services	145
6.1. Organization and Functions	145
6.2. Accomplishments, Future Plans and Limitations	145
7. Station Management	146
7.1. Background	146
7.2. General Objectives	146
7.3. Organization and Procedures	146
7.4. Staffing, Facilities and Equipment	147
7.5. Accomplishments	147
7.6. Future Plans and Constraints	147
7.7. Assessment and Recommendations	147
8. Plant Quarantine	148



	<u>Page</u>
CHAPTER G - COOPERATION WITH NATIONAL PROGRAMS AND OTHER CENTERS	149
1. Introduction	149
2. The Role and Functions of CIMMYT Regional Programs	149
2.1. Rationale	149
2.2. Responsibilities of CIMMYT Staff in Regional Programs	150
2.3. Criteria in Establishment of Regional Programs	151
2.4. CIMMYT's Achievements and Constraints in Regional Programs	156
3. The Role and Functions of CIMMYT in National Programs	156
3.1. Responsibilities of CIMMYT Staff in National Programs	157
3.2. Criteria Used in Establishing Bilateral Projects with National Programs	157
3.3. CIMMYT's Achievements in Bilateral Projects with National Programs	158
3.4. The Ghana National Maize Improvement Program	159
4. Collaboration with Other Centers	160
5. Assessment and Recommendations	161
5.1. Criteria in Establishment of Regional Programs	161
5.2. The Image and Coordination of CIMMYT Activities in Regional Programs	162
5.3. The Role and Future of Current Regional Programs	162
5.3.1. Programs in Eastern and Southern Africa (Wheat, Economics)	162
5.3.2. Programs in the Andean Region (Economics, Maize, Wheat)	163
5.3.3. Programs in South and South East Asia (Wheat, Maize, Economics)	164
5.3.4. Programs in the Central America and Caribbean Region (Maize, Economics)	164
5.3.5. Southern Cone Regional Wheat Program	165
5.3.6. North and West African Wheat Program	165
5.3.7. Mideast Regional Program - Relationship with ICARDA	165
5.3.8. West African Maize Regional Programs - Relationship with IITA	167
5.4. The Role and Future of CIMMYT in Bilateral Projects with National Programs	167
5.5. The Role of CIMMYT Personnel in Regional Programs	168
5.6. The Role of Regional Programs in Determining Research Priorities and Strategies	168

CHAPTER H - OVERALL ASSESSMENT OF ACHIEVEMENTS, IMPACT AND CONSTRAINTS	169
1. Review of the Recommendations of the First Quinquennial Review and Their Impact on CIMMYT's Program	169
2. Assessment of CIMMYT's Achievements and Impact during the Last Quinquennium	172
2.1. Preliminary Remarks	172
2.2. The Development and Distribution of Superior Germplasm	173
2.2.1. Wheat	173
2.2.2. Maize	175
2.3. Strengthening National Wheat and Maize Programs, including Manpower Development	177
2.4. Development of Research Methodologies and Techniques	180
2.5. Advances in Knowledge and Its Dissemination	181
2.6. Impact on Wheat and Maize Production	183
2.6.1. Wheat	183
2.6.2. Maize	184
2.6.3. Future Outlook	185
3. Constraints, Gaps and Related Problems during the Past Quinquennium	186
3.1. Constraints Due to Limitations in Available Resources and in Their Deployment	186
3.2. Constraints and Gaps Due to Present Internal Policies, Priorities and Structure	187
3.3. Constraints in CIMMYT Relationships with National Programs and Other IARCs	188
CHAPTER I - CIMMYT's LONG-TERM PLAN - OBSERVATIONS AND RECOMMENDATIONS	189
1. Preliminary Remarks	189
2. The Basic Premises of CIMMYT's Plans for the Next Five Years	189
3. Comparative Advantages, Future Mandate and Clarification of Functions of CIMMYT in the 1980s	190
3.1. CIMMYT's Comparative Advantages	190
3.2. Clarification of Functional Tasks	191
3.3. Mandate Revision	195
4. Future Strategies	196
5. Discussion of CIMMYT's Future Plans in Relation to Resource Requirements and Alternative Program Structures	196
5.1. Implications of CIMMYT's Planning Report for the 1980s	196
5.2. The "Minimum/Optimum" Alternative Plan	198
5.3. Funding the Additional Requirements	200

	<u>Page</u>
6. Alternative Structural Adjustments in Case of Major Changes in the Funding Level of CIMMYT and in the CGIAR System	201
6.1. A Plant Breeding Institute	201
6.2. A Center with Three Departments: for Maize Breeding, Wheat Breeding, and Wheat and Maize Production Research and Training	201
7. Conclusions	202
ACKNOWLEDGEMENTS	203

## ANNEXES

Annex I	- Composition of the Panel
Annex II	- List of Questions Supplementing the Terms of Reference Provided by TAC
Annex III	- Program and Itinerary of the Panel
Annex IV	- List of Documents
Annex V	- List of Trip Reports by Panel Members
Annex VI	- The Optimum Size of CIMMYT

## EXECUTIVE SUMMARY

1. Overview Assessment

The Review Panel was strongly impressed by the quality and dedication of CIMMYT's personnel, by its efficient management, and by its unstinting efforts in concentrating on practical targets with a clear sense of purpose and direction in research, training and service to the developing world. The Panel noted the excellent relations and support which CIMMYT enjoys not only with its host country but also with its many collaborators in practically all the maize and wheat producing countries in the developing world, as well as its growing links with the world's developed countries and with China in international testing and collaborative research. The Panel also noted that the impact of CIMMYT's research is felt not only in developing countries but also on the cereal production of many developed countries.

CIMMYT's achievements are very considerable.

Yet, for wheat the Center and its cooperators in National Programs have ahead of them a still formidable task in maintaining and further expanding the considerable gains which CIMMYT has provided in wheat production in developing countries. It has the opportunity of pushing further the frontiers of wheat production in marginal environments where many small farmers live, and addressing further the problems of environmental stresses and of coping with the continuously changing patterns of diseases and pests.

For maize, there are now clear indications in several countries of the pay-off and considerable potential of CIMMYT's efforts in improving maize for the tropical and sub-tropical world. The sudden rise over the last two years in the demands to CIMMYT for seed by many developing countries is a clear sign of the growing interest in the maize material developed by CIMMYT and its collaborators. At the the same time, some problems have still to be faced and resolved; in particular the development of resistance to several pests and diseases, the control of weeds

in the very aggressive environments of the humid tropics, and the fuller exploitation of CIMMYT-derived varieties by improved management practices and improved production of seed at the national level.

Looking to the longer term, the Panel has no doubt that CIMMYT's role will change as National Programs - despite their ebbs and flows - gain further strength and independence in research and varietal development. The current major strengths of the Center lie in its provision of advanced germplasm for distribution to National Programs and its contribution to the training of national scientists. In the future its role will shift to that of providing improved germplasm in a less developed state together with information about how to use it. It is essential that CIMMYT prepare for this challenge by appropriate shifts in its program goals to meet this inevitable change.

Both the achievements of CIMMYT during the past six years and the multiple research challenges which the Center is facing give ample justification for its continued support by the donor community and its many cooperators. The food gap in many developing regions still looms very large. The successes obtained so far remain fragile in a world with multiple threats due to the vagaries of climatic, socio-political and economic conditions and the ever present risk of epidemics, along with a continuously growing number of poor people who have fundamental rights and needs for more and better food and improved standards of living.

## 2. The Review

An eight-member Panel first visited, in small groups, countries in Asia, Africa and the Americas where CIMMYT carries out its regional programs and collaborative national projects. The Panel then reviewed the CIMMYT programs at its headquarters and main stations in Mexico, and had ample discussions with the Center's Directing Staff and its senior staff. Before issuing its report the Panel also had discussions with the Center's Board of Trustees. The Panel was guided by TAC's general instructions for quinquennial reviews, the standard terms of reference (Chapter A) and a list of questions to be specifically addressed (Annex II).

### 3. The Report

Following the Introduction (Chapter A), the report has three main parts: an analysis of the mandate, general objectives, organization and management of the Center (Chapter B); a detailed review of the objectives, contents, results, constraints and future plans of each main program and activity in Chapters C to G, with each Chapter containing an assessment and recommendations on the program under review; an overall assessment of the Center's achievements and constraints is presented in Chapter H, and Chapter I concludes the report with a review of the Center's future strategies and plans, a discussion of alternatives for its future role, and recommendations on its need for resources over the next five years.

The report reflects the unanimous views of the Panel.

### 4. The Mandate and Its Interpretation

The Panel notes that the functions, nature and scope of activities of CIMMYT have evolved since 1966, while the mandate has remained unchanged. The Panel recommends that CIMMYT's mandate be revised and up-dated so as to accommodate the Center's present and future objectives, to indicate its global responsibilities for specific crops in relation to the mandates of other IARCs, and to show its main thrusts. The Panel also recommends that steps be taken so as to give CIMMYT a legal international status in Mexico similar to that of other IARCs in their host country (see Chapter B, sections 2 and 4).

### 5. The Main Results of the Past Quinquennium

The results of CIMMYT's programs since its previous quinquennial review in 1976 are many (see Chapter H). The most important are:

- (i) A further increase both in the yielding capacity and in the yield dependability of bread wheat, durum wheat, triticale and barley, including in some marginal environments, improved resistance to diseases and tolerance to environmental stresses. Triticale now

nearly equals the best bread wheat lines in yield and grain quality (with superior protein quality) and so far shows broad resistance to disease and adaptation to environments that are marginal for wheat.

- (ii) The Maize Breeding Program has developed a unique and effective approach through population improvement for serving the needs of National Programs in developing countries. Considerable progress has been made in the improvement of the yielding capacity, agronomic characteristics, disease and insect resistance of a wide range of maize germplasm populations adapted to the diverse demands and conditions in developing countries. The network of cooperating plant breeders from National Programs and CIMMYT has doubled in size and presently includes virtually all of the developing countries which produce maize. The successful incorporation of opaque-2 and modifier genes into maize populations has produced materials with higher protein quality and improved grain type and yield.
- (iii) The development and wide dissemination by the Economics Program of a methodology for on-farm research enhancing the relevance of research objectives and the adaptation of CIMMYT-derived technologies to better suit farmer circumstances, particularly those of the small farmer.
- (iv) A steady flow of trainees from the maize and wheat training courses in breeding and production, and the development of training courses in economics and in station management.
- (v) The substantial development of regional programs servicing the different developing regions in maize and wheat breeding and related agronomy, economics and in-service training.

## 6. CIMMYT's Impact

CIMMYT's impact on wheat and maize production via its cooperators in National Programs depends on many factors, a large number of which extend beyond the mandate of the Center. Nevertheless, some 70 CIMMYT-derived open-pollinated varieties and hybrids of maize have been released by National Programs during the last three years. As regards wheat, barley

and triticale, numerous CIMMYT-derived varieties continued to appear. With the help of CIMMYT-derived material, training and consultation, Bangladesh for example has raised its production from less than 0.2 to 1.0 million tons in five years. Impact on maize production in the developing countries is necessarily more difficult to achieve and to quantify because maize is mostly grown on small subsistence farms and, in the tropics, is subject to considerable problems of weeds, insects and diseases. Nevertheless, the Panel saw that with appropriate varieties, on-farm research and seed production methods promoted by CIMMYT in conjunction with its ex-trainees in National Programs, a number of countries or regions such as Guatemala, Ecuador, Thailand and northwest Pakistan are in the process of achieving substantial increases in maize production on both large and small holdings.

#### 7. Follow-up of the First Quinquennial Review

The first review had given a broad endorsement to the strategies and methods of CIMMYT. While the greater part of the recommendations of the first quinquennial review have been implemented, the implementation of others, such as a greater involvement in disciplinary research, the collection of data on the production environments of wheat and maize, the development of expanded data processing capabilities, improved policies for recruitment and professional advancement, were delayed. These delays occurred mainly because of financial constraints during the last three years, but also because of a deliberate policy of the Center to give priority to field research, training and technology transfer by outposting staff in a growing number of regional programs.

#### 8. Future Strategies and Plans and Related Requirements

The Panel generally supports the research and technology transfer strategies outlined in the long-term plans of CIMMYT for the 1980s but recommends the following changes in emphasis and clarification of focus:

- (i) An increasing role in germplasm development, and the necessary supportive disciplinary research activities, to make possible further gains in yield potential, resistance to diseases and



- insects, and tolerance to a wider range of environmental stresses and adverse soil factors.
- (ii) A re-examination of CIMMYT's role and responsibilities, as an international center, in long-term conservation of germplasm, in consultation with IBPGR and other institutions.
  - (iii) An overall expansion, upgrading and integration of training activities at headquarters, and a more active role in developing training capacities and training courses in the regions in cooperation with other Centers, National Programs and bilateral/multilateral assistance programs.
  - (iv) A further increase of CIMMYT's activities in support of accelerated programs of seed production in developing countries, essentially aiming at increasing the participation of national breeders and other scientists in improving seed production.
  - (v) A fuller interpretation of the considerable amount of data flowing from international screening and performance trials.
  - (vi) Increased analysis, evaluation and reporting of the methodologies of the breeding programs.
  - (vii) A closer integration of agronomy and economics in on-farm research and a clarification of the different multiple roles of agronomists at headquarters and off campus.
  - (viii) Increased efforts in gathering and analyzing available information on the production environments of maize and wheat and their economics in various parts of the world, as an essential input to the Center's process of program formulation and priority setting, in particular for the regional activities.

## 9. Future Resource Requirements and Allocation

With amendments, the Panel supports the "minimum/optimum model" presented to it for CIMMYT's international staff requirements over the next five years. The Panel recommends, that, along with the necessary flexibility which should continue to be given to Management in seeking different sources of funds, the proposed model be amended as follows:

- (i) To be more selective in the number and sizes of the proposed regional programs particularly in wheat, and seek alternative ways

of discharging regional program functions in cooperation with other Centers and advanced research programs in developing countries.

- (ii) Provide relatively more resources for the Maize Program to capitalize on its present momentum.
- (iii) To establish the following new international staff positions at headquarters in the priority order:
  - (1) one crop physiologist/agronomist to serve both the Wheat and Maize Programs;
  - (2) a Director of Training;
  - (3) a senior breeder with competence in quantitative genetics in the Maize Program;
  - (4) a senior breeder/geneticist in the Wheat Program;
  - (5) a statistician/computer scientist;
  - (6) an additional maize pathologist.
- (iv) To provide additional means and facilities at headquarters for an expanded training program, and a more active role of the Center in publishing training manuals.

The Panel recognizes that these amendments have funding implications. Some of the necessary resources could be provided by rationalization of the Center's existing activities, the remainder in the opinion of the Panel would be justified as additional funding. These aspects are further elaborated in Chapter I.

The Panel considered alternative structural changes to the organization of the Center for the short and long term under various funding scenarios. It came to the conclusion that in the prevailing financial circumstances the Center's proposed "minimum/optimum" plan as amended by the Panel represents CIMMYT's best plan for the next five years. Funds permitting, this would at least ensure continuance of CIMMYT's contribution to the enhancement of wheat and maize research and production in developing countries at a minimum tolerable level. At the same time, the Panel encourages CIMMYT's Board of Trustees to examine possible changes to the Center's overall organizational structure which may be more in keeping with its longer-term role as National Programs develop.

## 10. Other Recommendations

The Panel presents a number of more detailed recommendations within or at the end of each Chapter. Some recommendations concern the scientific conduct of the Programs, while others deal more specifically with priorities, future requirements and management in each of the program areas of the Center. Several of these require support through normal or special sources of funding.

## 11. Conclusion

The Panel is convinced that its recommendations on the future plans of CIMMYT and their funding are fully justified by the impressive achievements of the Center during the past quinquennium and its potential for further impact on wheat and maize production in the developing world.

## CHAPTER A

### INTRODUCTION

#### 1. Introduction

A.1. The Consultative Group on International Agricultural Research (CGIAR) in 1973 instituted a procedure of independent review and evaluation of the work of the International Agricultural Research Centres (IARCs), which it finances. The CGIAR charged its Technical Advisory Committee (TAC) with organizing these external assessments in cooperation with the IARC concerned on a periodic basis of approximately five years and to report the findings and its judgements to the Group.

A.2. The first quinquennial review of the Centro Internacional de Mejoramiento de Maiz y Trigo (International Maize and Wheat Improvement Center or CIMMYT) followed that of the International Rice Research Institute (IRRI) held in December 1975. An independent panel reviewed the activities of CIMMYT in Mexico from March 21 to April 4, 1976. As a complement to this review of CIMMYT's activities in its host country, a smaller group of panel members examined the off-campus activities of CIMMYT in Tunisia and Egypt in September 1976. The report of the Panel was then submitted to TAC and after discussion, its recommendations were generally endorsed by the Committee, the CGIAR and the Center. The report of the first quinquennial review served as a key reference document for the second review. The assessment of the impact of the first review is presented in chapter H.

A.3. TAC and CIMMYT decided to conduct the second quinquennial review of the Center in 1982. By this time several other IARC reviews had been carried out and their objectives and scope had evolved in the light of the acquired experience and the demands of the CGIAR for a greater accountability of the Centers. In consequence, the Terms of Reference for such reviews had been modified so as to cover not only aspects related to the scientific quality of the activities of the Centers, but also their relevance and impact in relation to the needs of the

developing countries and the most effective use of the resources of the donor members of the CGIAR. The procedures for the selection of the Panel and the conduct of the review had also been elaborated further by TAC and described in a set of guidelines which had been approved by the CGIAR and issued along with the revised formulation of the Terms of Reference.

A.4. After consultation with the Board of Trustees and the Directorate of CIMMYT, TAC entrusted the task of conducting the second review to Dr. J.L. Dillon, agricultural economist and Pro-Vice Chancellor, University of New England, Armidale, Australia, and seven other Panel members. The other Panel members were: Dr. A.E. Hall, crop physiologist and agronomist, University of California, Riverside/USA; Dr. J. E. Parlevliet, plant pathologist, Agricultural University, Wageningen, The Netherlands; Mr. G. Popow, former head of the plant breeding department of the Agricultural Research Institute Zurich-Reckenholz, Switzerland; Dr. C.O. Qualset, plant geneticist and breeder, university of California, Davis/USA; Dr. H.F. Robinson, quantitative geneticist and Chancellor, Western Carolina University, Cullowhee, USA; Dr. F.J. Wangati, agrometeorologist and Science Secretary, National Council for Science and Technology, Nairobi, Kenya. The Scientific Advisor of the CGIAR Secretariat, Dr. D.L. Plucknett, participated in the review. The Executive Secretary of TAC, Mr. P.J. Mahler, acted as Secretary of the Panel. Due to compelling family reasons, a member of the Panel, Dr. E. Alves, President of EMBRAPA, Brazil, was unable to participate. The composition of the Panel is given in Annex I.

## 2. Terms of Reference

A.5. The Terms of Reference for the second quinquennial review of CIMMYT were formulated by TAC as follows:

### Terms of Reference

The major objective of the mission has been defined by TAC (in agreement with the Directors of the International Centres, and accepted by the CGIAR) as follows:

"On behalf of the Consultative Group, to assess the content, quality, impact and value of the overall programme of the Centre and to examine whether the operations being funded are being carried out in line with declared policies and to acceptable standards of excellence".

It is hoped that the review will inter alia assist the International Centre itself in planning its programmes and ensuring the validity of the research priorities recognized by the Board of the Centre.

In pursuance of the main objectives, defined above, the Mission is requested to give particular attention to the following aspects:

- (i) The mandate of the Centre, its appropriateness and the interpretation thereof with respect to:
  - (a) the immediate and long-term needs for improved food supply and human welfare in developing countries;
  - (b) present and possible future areas of work;
- (ii) The relevance, scope and objectives of the present programme of work and budget of the Centre and of its forward plans for the next five years in relation to:
  - (a) its mandate and the criteria for the allocation of resources as defined by TAC;
  - (b) the ongoing activities of other international institutes and organizations, and of the relevant national institutes in cooperating countries and in others where the work of the institutes has bearing;
  - (c) the policy, strategy and procedures adopted by the Centre in carrying out its mandate, and the mechanisms for their formulation;
  - (d) the Centre's rationale for its present allocation of resources, its present and future overall size, and the composition and balance of the programme in the fields of research, training, documentation, information exchange and related cooperative activities.
- (iii) The content and quality of the scientific and related work of the Centre with particular reference to:
  - (a) the results of past research;
  - (b) the current and planned research and the role of the scientific disciplines therein;
  - (c) the information exchange and training programmes, their methodologies, their specialization and decentralization, and the participation of the research staff therein;
  - (d) the adequacy of the research support and other facilities;
  - (e) the management of the scientific and financial resources of the Centre and the coordination of its activities.
- (iv) The impact and usefulness of the Centre's activities in relation to:

- (a) the present and potential agricultural production of the relevant countries and regions;
  - (b) its information exchange and training programmes;
  - (c) cooperation with national research and development programmes;
  - (d) cooperation with other international institutes and organizations.
- (v) Constraints on the Centre's activities which may be hindering the achievement of its objectives and the implementation of its programmes, and possible means of reducing or eliminating such constraints.
- (vi) Any specific questions which concerned members of the CGIAR, cooperating institutions, the Centre's Director or its Board of Trustees, may request TAC to examine.

The quinquennial review mission should also assess the impact of the preceding quinquennial review on the programmes and activities of the Centre.

On the basis of its review, the Mission will report to the Chairman of TAC its views on the need for any changes in the basic objectives or orientation of the Centre's programme elements, and on means of improving the efficiency of operations, and will make proposals for overcoming any constraints identified under item (v).

While the Mission should feel free to make any observations or recommendations it wishes, it must be clearly understood that the Mission cannot commit the sponsoring organization, viz. the CGIAR/TAC.

A.6. The above Terms of Reference were supplemented by the standard guidelines for quinquennial reviews <sup>1/</sup> and by a list of questions which had been compiled from those raised by TAC and members of the CGIAR, and by CIMMYT's Board of Trustees, for this review (see Annex II).

### 3. The Review Procedure

A.7. The review was conducted in three main phases: starting in 1981 and until early September, 1982, a preparatory phase which included the planning of the review, the preparation of the documentation and the review of CIMMYT's off-campus activities outside Mexico; followed by the review of CIMMYT's activities in Mexico from September 5 to 24, 1982;

<sup>1/</sup> "Terms of reference and guidelines for quinquennial reviews". AGD/TAC: IAR/78/11 Rev. 2, TAC Secretariat, FAO, Rome, 1980.

and then the finalization of the review report, including further consultations with the Board and the Directorate of CIMMYT, and with TAC.

A.8. The review process started with a series of consultations between CIMMYT's Directorate and Board of Trustees on the one hand and TAC and its Secretariat on the other hand in 1981. In March 1982, the Chairman of the Panel attended the Presentation Week of CIMMYT and, together with the Panel's Secretary, met with CIMMYT's Program Committee and Directorate at CIMMYT's headquarters at El Batan, Mexico. The program of the review and the composition of the Panel were then finalized.

A.9. In the meantime, visits to several countries where CIMMYT has cooperative activities with National Programs had been initiated and continued until the Panel assembled at El Batan on September 5, 1982. The schedule of these visits was as follows:

- 1) Thailand, Bangladesh, Pakistan from February 21 to March 7, 1982 by Drs. J.L. Dillon and C.O. Qualset;
- 2) Turkey from March 8 to 10 by Dr. C.O. Qualset;
- 3) Ecuador from July 4 to 9 by Dr. H.F. Robinson (leader), Dr. A.E. Hall, Mr. G. Popow and Mr. P.J. Mahler;
- 4) Oregon State University, U.S.A. (the spring x winter wheat cooperative program) from July 11 to 14 by Dr. C.O. Qualset (leader), Dr. A.E. Hall and Mr. P.J. Mahler;
- 5) Kenya from August 5 to 7 by Dr. J.L. Dillon;
- 6) Ghana and Nigeria (including IITA) from August 8 to 17 by Dr. J.L. Dillon, Mr. G. Popow and Dr. F.J. Wangati;
- 7) ICARDA Headquarters, Aleppo, Syria from August 29 to September 1 by Mr. G. Popow.

A.10. During the visits, the Panel members were accompanied by relevant members of CIMMYT's Directorate and met both with the local CIMMYT staff and representatives of the National and Regional Programs and/or the IARCs concerned. The findings from these visits were reported to the whole Panel at El Batan during the second phase of the review, at which time CIMMYT also had the opportunity to comment on these findings.



A.11. As detailed in Annex III, the second phase of the review in Mexico lasted three weeks and included a series of presentations by, and discussion with, the Directing Staff and relevant senior scientific staff at El Batan <sup>1/</sup>, and visits to the experimental fields, laboratories and other facilities at the El Batan headquarters and at Toluca, Tlaltizapan and Poza Rica Stations. During this period, four Panel members visited the cooperative maize program of CIMMYT with ICTA, Guatemala, while others visited highland areas in Mexico to see a series of trials on farmers' fields. At the end of the last week, the Panel met with the Board of Trustees, and discussed with them and with the Directorate and senior staff of the Center the preliminary findings and recommendations of the review.

#### 4. The Report

A.12. The draft report was subsequently presented to TAC at its 29th meeting in Washington, D.C. on November 4, 1982 in the presence of the Directorate of CIMMYT. The comments of TAC and CIMMYT were then reviewed by a drafting committee of the Panel and the report, after clearance with all Panel members, was submitted to TAC at its 30th meeting in March 1983.

A.13. For the review, the Panel was given a considerable number of documents including CIMMYT's publications during the last quinquennium, its long-term plan, and the 1983/84 budget request, as well as other documents which were specifically prepared for the briefing of the Panel. The list of these documents is given in Annex IV.

A.14. Beside the overview of the Panel's findings and recommendations presented as an Executive Summary at the beginning of the present document, this introduction is followed by a series of analytical chapters reviewing the mandate, organization and management of the Center, its main programs including

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<sup>1/</sup> Several members of the CIMMYT Regional Programs and field projects were also in attendance during this second phase of the review.

the supportive research and services, and the cooperative activities of the Center. In the penultimate chapter, an overall assessment is presented, including a review of the impact of the first quinquennial review on the programs of the Center and an appraisal of the Center's achievements over the last six years. The implications of the recommendations of the Panel on the Center's program for the next five years are then discussed in the last chapter.

## CHAPTER B

MANDATE, STRATEGY, OVERALL ORGANIZATION AND MANAGEMENT1. Introduction

B.1. The history of CIMMYT is generally traced to the year 1943, when the original cooperative project was initiated by the Mexican Department of Agriculture and the Rockefeller Foundation. Under this project, a group of agricultural experts was sent to Mexico to cooperate in a joint program of investigation and demonstration for the benefit of Mexican agriculture. These efforts involved fundamental investigations, including genetic studies to improve maize varieties and other important plants; control of wheat diseases and other plant diseases of major importance; studies of soils for the purpose of increasing the productivity of the soil; and other similar projects of investigation which were to be selected by mutual agreement. This joint project continued for nearly two decades.

B.2. In 1961 Mexico established the National Institute for Agricultural Investigations (INIA), and assigned to it the principal responsibility for carrying out research to meet the needs of Mexican agriculture. Concurrently, the Rockefeller Foundation group based in Mexico began to extend its activities to other countries in Central and South America and later to Asia and other parts of the world.

B.3. Many of the concepts that were developed during this early period provided the rationale and the guiding principles for CIMMYT's development and mode of operation; indeed, for the IARCs in general. The research philosophy was guided by a "primary consideration aimed towards solving the immediate production problems of the farmers." Training of individuals to work on problems at a national level was a major focus of program activity. This continues in CIMMYT today.

## 2. Mandate of CIMMYT and Its Interpretation

B.4. In 1966 CIMMYT was formally organized with financial support mainly provided by the Rockefeller and Ford Foundations. On April 12, 1966, an agreement was signed establishing CIMMYT as a legal entity in Mexico with the following mandate.

- (a) "To promote and carry out, nationally and internationally, programs to improve in all its aspects maize and wheat production and if advisable, the production of sorghum, rice, and other food crops, in order to obtain greater unit yields and better production and quality of these crops.
- (b) To carry out basic and applied research activities in order to achieve the purpose mentioned in the preceding point.
- (c) To prepare and distribute superior genetic material, which will permit the achievement of higher yield standards and better quality of crops.
- (d) To carry out locally and internationally, training programs for the preparation of scientists and technicians with the necessary experience in research and in the application of results, relevant to the activities of the center.
- (e) To promote and participate in the conduct, locally and internationally, of all kinds of scientific and technical meetings and, of any activity directed to obtaining close cooperation among scientists engaged in programs for the improvement of cereal production, as well as of the interested sectors in any part of the world.
- (f) To publish and distribute the results obtained from research programs and carry out what may be necessary to promote the immediate and efficient application of these results to the improvement of quantity and quality of maize, wheat and other important food crops on a local and international level."

B.5. With the creation of the CGIAR in 1971, CIMMYT became a member of the Centers supported by the Group. However, its mandate has not been amended even though responsibilities for sorghum and rice, for example, have been given to other Centers.

B.6. It is stated in publications produced and distributed by CIMMYT that the Center "limits its research to maize, bread wheat, durum wheat, barley and triticale" and the Center states<sup>1/</sup> that it fulfills its mission in the following ways:

- "1. Conducting research in Mexico and elsewhere.
2. Distributing superior germplasm to national programs in order to obtain higher and more dependable yields and improved quality.
3. Developing procedures for crop improvement and crop management research.
4. Conducting applied training for scientists from developing countries.
5. Sponsoring technical seminars.
6. Publishing information on new technological components.
7. Consulting with scientists and governments in developing countries on the organization of maize and wheat research and production programs.
8. Posting of staff members outside Mexico to work in regional and national programs."

B.7. The Panel noted the following differences between the mandate of CIMMYT as specified in 1966 and the interpretation as stated above:

- (i) The interpretation of the mandate clearly specifies that CIMMYT works on a limited number of cereals. It reaffirms its focus on research and distribution of superior germplasm but omits mention of "basic and applied" research. Yield dependability is included as one of the objectives beside "greater unit yield" and "better quality." The "development of [research] procedures" is stated as one of the means of achieving the stated objectives.

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<sup>1/</sup> Briefing book, 1982 Quinquennial Review, CIMMYT, August 11, 1982.

- (ii) There is an explicit mention of developing countries in the stated objectives of the Center, whereas the mandate merely refers to the international role of CIMMYT. This mention of developing countries is specifically introduced in two (and only two) of the functional tasks which CIMMYT sets for itself in "applied training for scientists" and consultations for "the organization of maize and wheat research and production programs" in these countries.
- (iii) The broad role of CIMMYT in information exchange and dissemination as given in the mandate is apparently interpreted in a more restrictive manner in the above statement of objectives. In principle, CIMMYT would confine its activities in this field to "sponsoring technical seminars" (actual participation is omitted as well as mention of "scientific meetings"). The objective would be to publish information only on "new technological components" rather than research findings as indicated in the 1966 mandate.
- (iv) The CIMMYT mandate, as stated in 1966, expressly covers maize and wheat research but does not imply or state directly a worldwide mandate for these crops. By its actions CIMMYT has verified its interest in a worldwide mandate in maize and wheat. The mandate does indicate the international nature of CIMMYT "to improve in all aspects maize and wheat production" but does not specify how these international relationships might take place <sup>1/</sup>.
- (v) Given CIMMYT's interpretation of its world mandate for maize and wheat, there is a degree of overlap of crop mandates between CIMMYT and ICARDA (bread wheat, triticale, barley, durum wheat) and IITA (maize in Africa). Moreover, the part in the mandate referring to sorghum, rice and other food crops would appear to be anomalous.

B.8. Neither the mandate nor its interpretation includes any explicit mention of the role of CIMMYT in germplasm conservation nor of the relationship of CIMMYT with other IARCs.

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<sup>1/</sup> It should be noted that this includes both spring and winter wheat, whereas CIMMYT's work concentrates mostly on spring wheat.

B.9. Study by the Panel of the minutes of the Board of Trustees indicates that there has been no formal acceptance by the Board of any revision of the 1966 mandate. As indicated in the Report of the first quinquennial review, the CIMMYT Board reaffirmed in 1973 that the mandate of the Center is "to improve the quality and quantity of maize and wheat wherever they can be grown efficiently in the world especially in the developing countries." In addition, CIMMYT, with the approval of its Board of Trustees, had become involved in programs related to barley, sorghum and triticale. CIMMYT's work on sorghum for the high-lands of Latin America then became part of ICRISAT's program in 1977, and CIMMYT now hosts a sorghum breeder from ICRISAT on its campus. The relationships with ICARDA on barley and with IITA on maize are more complex and will be reviewed in Chapter G.

B.10. It is worth noting that the first quinquennial review Panel (1976) identified several of the anomalies which have been listed above in the mandate of CIMMYT and its interpretation, in particular as regards the lack of reference to the relationships not only with other Centers but also with basic research institutions. The first quinquennial review Panel indicated also that the degree of involvement of CIMMYT in National Programs and in cereal production in general should be clarified. The first quinquennial review Panel, however, concluded that, in general, the mandate of CIMMYT had been interpreted in a realistic and appropriate manner and did not suggest that it be amended. Instead, it made several recommendations as regards the scope of the future work of CIMMYT in the areas where the interpretation of the mandate of the Center required some clarification or changes. The impact of these recommendations is examined in Chapter H and, in the light of the findings of this second quinquennial review, it is felt that the changes which have taken place in the scope of CIMMYT's work and in its strategies should be taken into account in setting its future objectives and adequately reflected in a revised statement of its mandate.

B.11. The Panel recommends that the mandate of CIMMYT be revised with the aim of better reflecting its present interpretation in regard to its scope, nature and relationships with National Programs and other IARCs,

and responsibilities relative to germplasm conservation, evaluation, and utilization.

### 3. Strategy

B.12. CIMMYT's strategy in discharging its mandate and pursuing its objectives as stated in the preceding sections has remained basically unchanged since the first quinquennial review. The Panel of the first review had noted that "CIMMYT sees its purpose as principally to apply existing knowledge to the improvement of cereal production, especially in developing countries, rather than to become closely involved in the creation of new knowledge." CIMMYT considers itself an applied research center, but considers it important to establish and maintain liaison with basic research institutions, mainly through collaborative research programs.

B.13. The CIMMYT strategy for the improvement of cereal production continues to concentrate on the development and utilization of superior germplasm of wheat and maize. The Center relies on an intensive program of applied plant breeding to develop improved germplasm applicable to agricultural production in developing countries.

B.14. The Center seeks to develop widely adapted germplasm with resistance to major pests and diseases and with tolerance to climatic and soil stresses. These materials are distributed through networks of international trials and nurseries.

B.15. Training is a high priority and essential element of the CIMMYT strategy. Training is an integral part of each of the three major programs and of the supportive services, and trainees are involved directly in the work of each crop program.

B.16. CIMMYT assists National Programs by providing improved germplasm, training for local wheat and maize workers, and by direct involvement in some circumstances. CIMMYT follows a regional approach in its efforts to assist National Programs. To carry out its Regional Programs, CIMMYT



stations its staff in key locations in the region and then assists in the identification and rapid dissemination through National Programs of improved varieties resulting from its breeding programs. In certain situations, CIMMYT staff members are assigned to National Programs to assist and support national crop improvement and production activities.

B. 17. In its networking activities in Regional and National Programs, CIMMYT relies heavily on its hundreds of former trainees who are familiar with CIMMYT programs and procedures, and are ready and willing to cooperate.

B.18. Although CIMMYT's strategy remained essentially the same over the last six years, the Panel noted several changes of emphasis:

- (i) While breeding continues to be a key function of CIMMYT, there is a growing realization of the obstacles which limit the impact of high yielding varieties on production. The importance of stable resistance to pests and diseases, of appropriate cultural practices, of efficient use of inputs, of sound policies and adequate delivery services, is given increased recognition in CIMMYT's programs. As the control of these factors tends to be location-specific, CIMMYT's strategy is to give growing emphasis to these aspects by outpostting an appropriate number of staff in the relevant disciplines (agronomy, pathology, economics) in Regional and National Programs.
- (ii) Another major development in CIMMYT's strategies over the last six years has been the formulation of methodologies for on-farm research as a means to ensure the relevance of research to the problems of farmers, to understand better the constraints to improved cereal production, and to develop sets of adapted technologies which can enhance the impact of CIMMYT's breeding programs.
- (iii) While CIMMYT has always maintained links with research institutions in developed countries, there has been a growing number of collaborative research arrangements with such institutions over the last six years.

- (iv) The scale and the timing of the operations of CIMMYT combined with reduced staff numbers leave little opportunity for the staff to pursue new methods of analysis and interpretation of research data. The new data processing facilities which have just been installed at CIMMYT headquarters offer substantially greater scope for data processing and interpretation. There are already some indications of the contributions which these approaches can make in setting priorities within and across the Center's programs.
- (v) As National Programs in some developing countries have acquired greater competence and capacity, the relationships between CIMMYT and these programs have evolved towards a more equal partnership basis. Collaborative research and cooperation in special breeding programs have increased with the more advanced developing countries. In these countries there also has been a decrease in the delivery of semi-finished varieties from CIMMYT and a greater use of CIMMYT gene pools, crossing blocks and segregating populations.
- (vi) Recent experience has shown that in the regions and countries where CIMMYT has had important impact and where its technologies have been successfully adopted, there is a need for CIMMYT to continue to devote some research resources to help ensure that the high genetic potentials for crop yields are not allowed to be eroded by new diseases that may result following the continuing genetic evolution of the populations of pests and diseases. Also, CIMMYT can play an important supporting and stimulating role with National Programs, and it is necessary to maintain some relationships with National Programs even when they are strong. The role of germplasm banks and of the international testing networks (the disease surveillance nurseries in particular), and of the outposted staff of CIMMYT in diverse regions and countries, are seen to be essential to the identification and solution of problems before they become too serious. The maintenance of the gains obtained through higher and more stable yields and their further improvement require increasing attention. Far from calling for routine activities, the preservation and further development of genetic gains give a new dimension to the international testing networks

and call for a wider use of new combinations of germplasm, as well as for new initiatives in basic research and experimentation.

The evolution of CIMMYT's strategies are addressed further in conjunction with the consideration of the future plans of the Center in Chapter I.

#### 4. Legal Status of CIMMYT in Mexico

B.19. CIMMYT was founded by the Mexican Ministry of Agriculture and Animal Husbandry and the Rockefeller Foundation in 1966. On 4 December 1969 the President of Mexico signed a Presidential Decree recognizing CIMMYT's international character and stating that the Ministries of the Treasury and Public Credit, Industry and Commerce, Foreign Relations, Government and Agriculture would provide CIMMYT the facilities required for the full development of its activities. However, the Center was established as a civil association of Mexico and its legal status has remained unchanged.

B.20. Today CIMMYT is the only IARC in the CGIAR system without true international status. The lack of international status has led to some difficulties in operation including:

- (1) those relating to operations outside Mexico,
- (2) those relating to visa regulations for international staff,
- (3) those relating to importation of scientific equipment and supplies,
- (4) those relating to taxation and fiscal management, and more recently,
- (5) currency controls which impede the functioning of the Center.

Some of these difficulties have been minor at times; at other times they have been more significant.

B.21. The Panel considers that the international status of CIMMYT is an important problem that should be addressed. Therefore the Panel

recommends that the Board of Trustees and the management of CIMMYT take immediate steps to obtain complete international status, and that the revised mandate and international status of CIMMYT be defined and legalized in the necessary agreements with Mexico. Further, if CIMMYT cannot, in a relatively short time, resolve the situation through its own resources, the Panel hopes that the three co-sponsors of the CGIAR (FAO, UNDP, World Bank) could use their good offices to assist in resolving the problem, so that CIMMYT's worldwide programs and efficiency will not be impaired.

##### 5. Organization, Administration and Management

B.22. CIMMYT's headquarters located at El Batan, Mexico, and supported by seven other substations in Mexico, are essentially complete and have undergone relatively minor changes since their original development. A number of facilities have been added in recent years, including a wheat germplasm bank and a computing facility with new equipment, a VAX 780. Although housing facilities are quite adequate for postdoctoral fellows, visiting and associate scientists, and in-service trainees, there is a need to expand the cafeteria and to build a Training Center. Regular staff live in private housing in the vicinity of El Batan or in Mexico City, some 40 km away.

B.23. CIMMYT has an autonomous Board of Trustees that is non-political, involving 15 members appointed for one or more three-year terms. The Mexican Minister of Agriculture, the Director General of INIA, and the CIMMYT Director General are ex-officio members of the Board. The remaining 12 members of the Board, among whom are a number of members from developing countries, are elected by the full Board. The annual Board meeting is generally held in March or April. The two standing committees of the Board, a combined Executive and Finance Committee and the Program Committee, meet on average twice per year.

B.24. The Director General is assisted by two Deputy Directors General who serve as staff officers to him and also have direct supervisory responsibilities for the various administrative and research support

units of the center. The Deputy Director General for Administration is the CIMMYT treasurer and generally serves as Acting Director in the absence of the Director General. He is an employee of the Rockefeller Foundation and also holds the position of Associate Director Agricultural Programs for the Rockefeller Foundation. The Deputy Director General for Research is responsible for coordinating the development of proposals and the negotiating of grants with CGIAR donors and recipient countries; developing formal collaborative research arrangements; assisting the Director General in technical dialogues with the Trustees' Program Committee and TAC; and interacting with CIMMYT Program Directors in the coordination of overall research activities. The organizational structure of CIMMYT is presented in Figure B 1 which depicts only major categories of the organization.

B.25. The management philosophy of CIMMYT provides a high degree of centralization of decision making in the individual programs with the Director General using, as he states, the consensus management approach within the Directing Staff. The Directing Staff consists of the Director General, the two Deputy Directors General, three Program Directors and two Associate Program Directors. The Program Directors have the major role and authority in control of expenditures and decision making for their program. While there are mechanisms for individuals to voice their concern with regard to the management philosophy and decision making process, it should be stressed that Program Directors not only have the authority for major decisions with regard to the programs for which they have principal responsibilities, but also there is considerable autonomy in the operation of the three major programs. The strong focus of the crop programs on applied objectives may discourage outside ideas and consultation which could be beneficial to the overall programs of the Center.

B.26. Finally, as a part of the management technique, CIMMYT operates several committees. The operational Committees include (1) Library, (2) Data Processing, and (3) Publications. These committees have broad-based staff involvement and serve as sources of suggestions for policies and procedures of importance to the operations of CIMMYT.

## 6. Personnel

B.27. The personnel categories of CIMMYT are the following:

- International Staff
- Pre- and Postdoctoral Fellows
- Associate Scientists
- Support Staff
- Field Laborers
- Temporary Laborers.

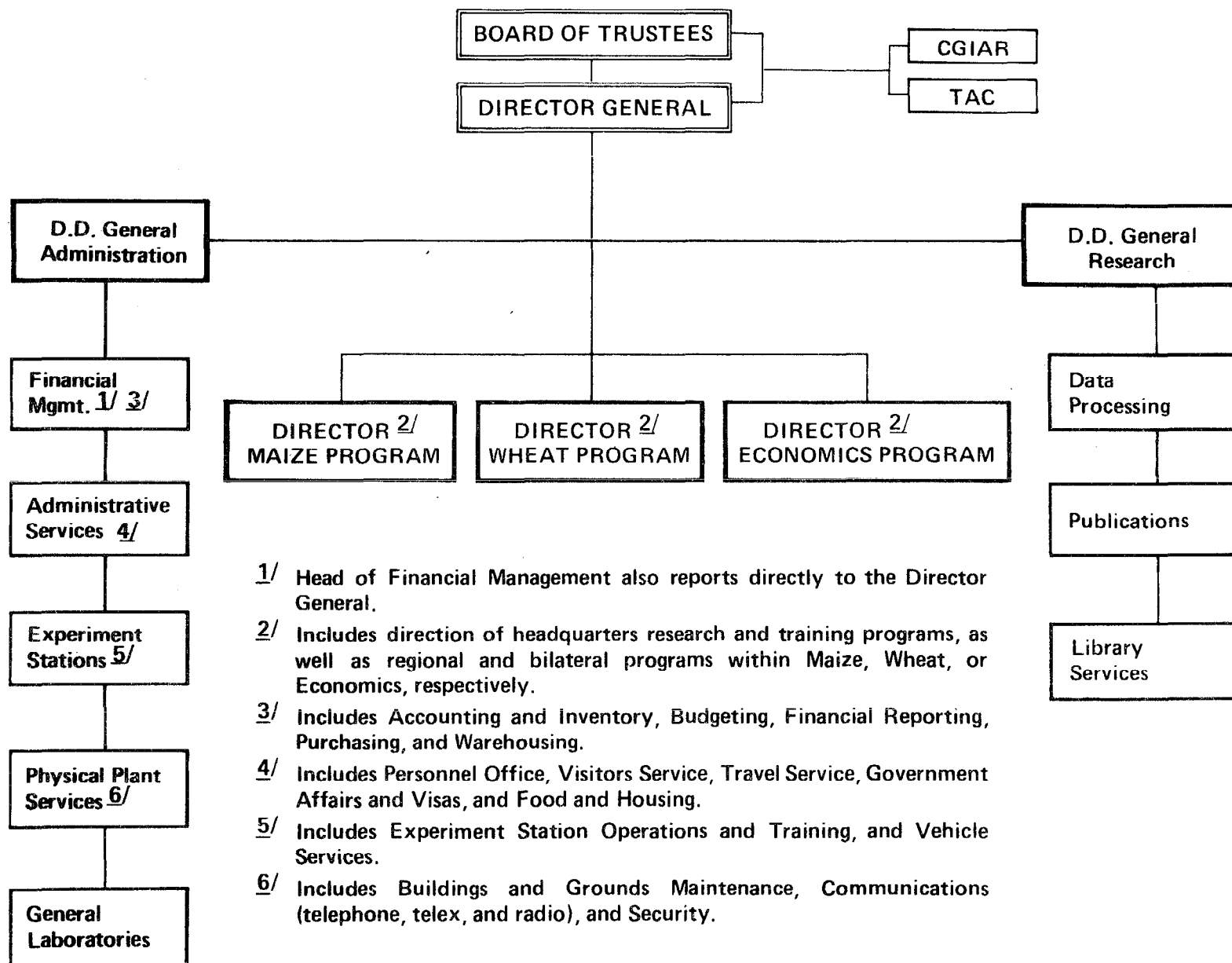
At the time of the Review, there were 72.0 man years budgeted for the international staff on core programs and 4.75 on extra core. Current estimates show an expected 69.5 core man years at the end of 1982 and 4.75 man years on extra core. Four postdoctoral fellows were filling vacancies. The above numbers contrast with 54.5 international staff on core programs and 15.5 on extra core in 1976. A major development has been the outposting of core staff in Regional Programs since 1976.

B.28. The support staff is classified by salary grade and at the time of the review numbered:

<u>Salary Grade</u>	<u>Man-years</u>	<u>Functional classification</u>
S-1	13	Senior supervisors (Technical and Administrative)
S-2	35	Assistant supervisors, Heads of Exp. Sta., Exec. Secs.
S-3	99	Bilingual secretaries, clerks
S-4	25	Junior secretaries, clerks
S-5	99	Lab. & Field assistants, Senior maintenance workers
S-6	124	Lab. & Field helpers, Junior maintenance workers
Subtotal	395	
Field laborers (full time)	150	
Temporary field laborers	140	
TOTAL	685	

Figure B1

# CIMMYT ORGANIZATIONAL STRUCTURE



B.29. Personnel management in CIMMYT is based on detailed regulations which have been compiled in a manual. As a matter of Management policy, except for the Director General, international staff are on fixed-term renewable one-year contracts.

#### 6.1 General Comments on Administration of Personnel

B.30. The personnel were found to be quite dedicated and capable in performing the required functions. From the Director General throughout the personnel in the organization, there appeared openness in the operation, and dedication to CIMMYT programs and objectives by an extremely hard working staff. As indicated earlier, a high degree of decision making continues to reside with the Program Directors.

#### 6.2 Recruitment of Personnel

B.31. With present budget stringency, little or no growth in the number of international scientists can be expected. Except for major directing staff replacements, personnel changes will likely continue to be in the postdoctoral fellowship category.

B.32. Postdoctoral fellows currently provide the main avenue for international research staff recruitment at CIMMYT. Fellows are employed in the Programs for two-year periods. During this period they are not assigned independent disciplinary research responsibilities, but are utilized in the Programs as needed. They learn the CIMMYT approach and philosophy and, if mutually agreeable and a position is available, they are appointed to the international staff. Many of the present staff have been recruited and employed in this manner, and some have advanced to become key personnel at headquarters and in regional and country programs.

B.33. The Panel, while recognizing the value and importance of the postdoctoral program, also wishes to sound a note of caution against using this approach as the major recruiting tool for the professional staff at CIMMYT. The Panel sees some danger of inbreeding and possible



isolation from research elsewhere if CIMMYT continues to hire mainly its postdoctoral fellows for international research staff positions. The Panel recommends that CIMMYT should advertise vacancies in international staff positions in order to have the widest possible array of talent available from which to choose scientists to bring new ideas and approaches to the research programs.

### 6.3 Utilization of Postdoctoral Fellows

B.34. The Panel wishes to caution against the use of postdoctoral fellows in areas considered not in the best interest of these individuals or CIMMYT. There exists the possibility of using these individuals for the performance of menial tasks for extended periods of time, and not utilizing his or her abilities. At the other extreme is the use of relatively inexperienced postdoctoral fellows for filling, often temporarily, positions normally held by senior staff.

### 6.4 Professional Development of Staff

B.35. Operating an international center such as CIMMYT with its diverse locations in the developing world creates some problems for the staff in their maintaining the highest possible level of performance in their scientific disciplines. This problem increases in magnitude with the extremely heavy need for travel among the developing countries. There is clear recognition of the problem by the Director General, yet a suitable solution or plan of action to alleviate the difficulties were not evident. Arrangements need to be formalized for study leave away from CIMMYT for key individuals. Furthermore, there is need for more time for personal intellectual advancement since the routine activities that they perform are so demanding that the longevity of effective and productive output may suffer.

## 7. Financial Resources and Management of Funds

B.36. Funds for CIMMYT come from three principal sources: (1) grants from CGIAR and other donors, (2) earned income (service fees, interest

on deposits and sale of commodities), and (3), under certain conditions, funds carried forward.

B.37. Earned income is merged into a common pool becoming part of the total resources available for meeting budget requirements in that year. The earned income is variable and unpredictable, amounting to less than 5 percent of the total budget.

B.38. The major funding for CIMMYT comes from CGIAR, amounting to about 90 percent of the total resources available. Of these funds, 80 percent are unrestricted core grants and the remainder are restricted core grants. Since 1976, special project grants have averaged about 10 percent of the total funds of the Center. The funding pattern showing the distribution of the various core and extra core funds from 1976 to 1983 is shown in Figure B 2.

B.39. Core unrestricted funds provide maximum flexibility and can be allocated as needed across programs and are therefore of great value to Center Management.

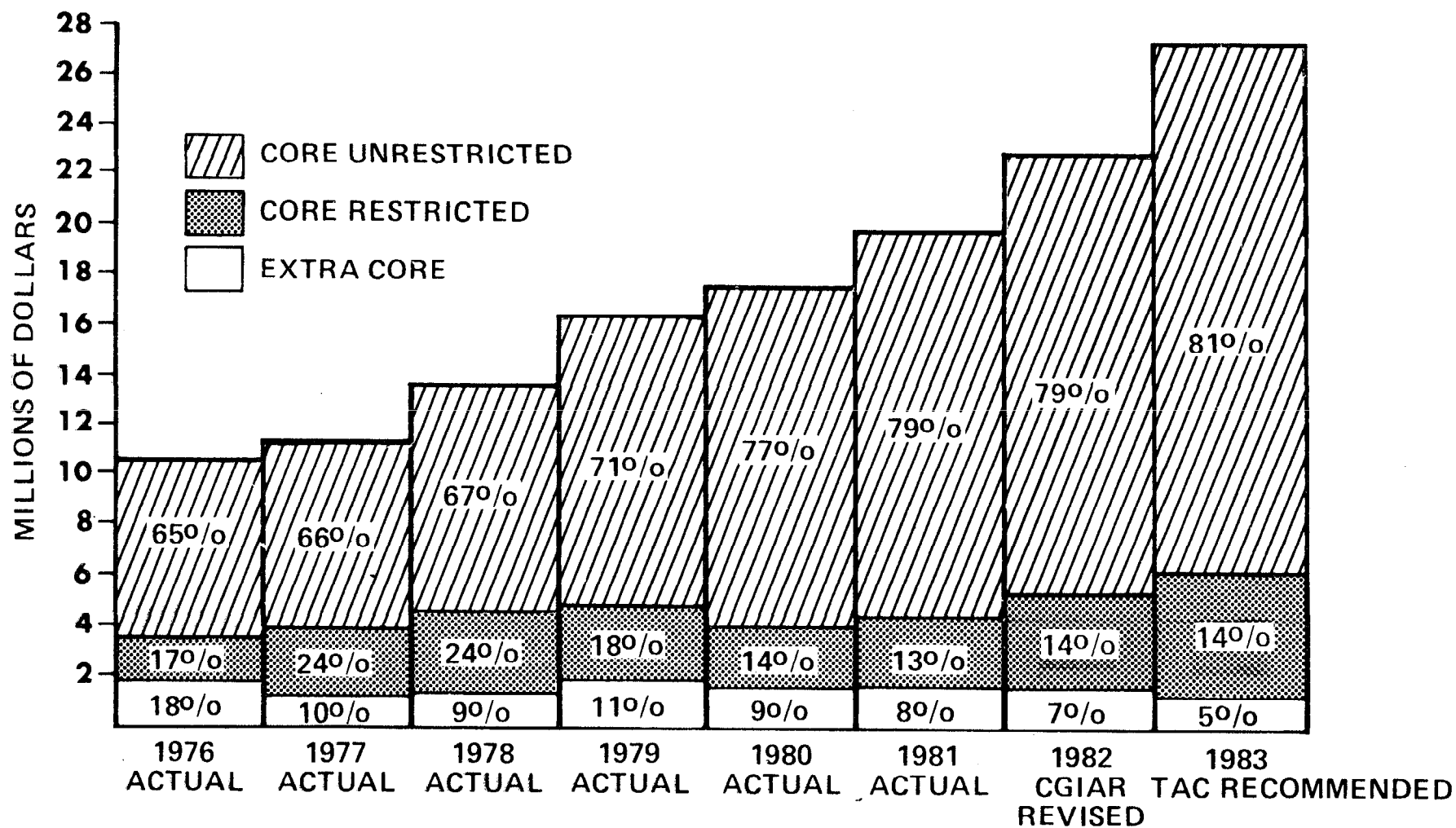
B.40. Particularly in times of budget stringency, restricted core funds provide much less flexibility to Center Management. They also require added monitoring, accounting and reporting. When financial resources are increasing, restricted core funds cause little difficulty to the operation of a Center. However, with levelling and decreasing resources, restricted core funds are more difficult to administer because in the short run it is difficult if not impossible to shift funds from lower to higher priority activities. The Panel notes with some concern the increasing proportion of the CIMMYT budget being funded through restricted core grants.

B.41. Special project extra core grants (the relative magnitude of these grants in total funding is shown in Figure B 2) carry with them a monitoring, accounting and reporting burden similar to restricted core funds and also provide limited flexibility. They may, however, provide a more flexible approach to staff development and deployment, assist in

Figure B2

# FUNDING PATTERNS

DISTRIBUTION OF OPERATING PROGRAMS



SOURCE: CIMMYT BUDGET DOCUMENTS

the development of new research procedures, and provide research results which are applicable beyond the particular special project. The Panel notes that CIMMYT has a relatively low level of special project funding, which is commendable. However, it has been observed that many opportunities are available for research for which special funds could probably be obtained.

### 7.1 Budget

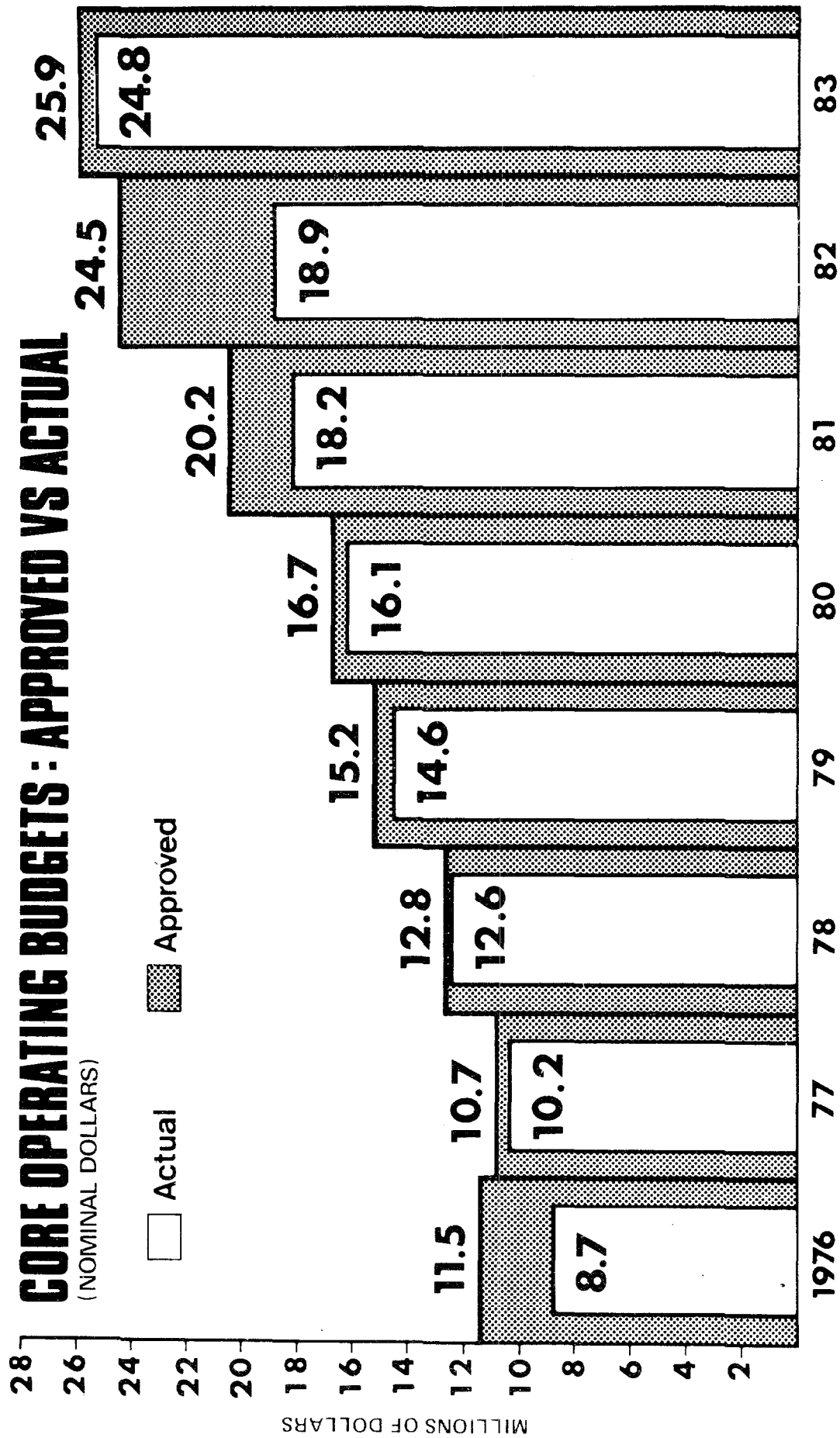
B.42. Particularly in the last two years, CIMMYT has had serious problems created by the discrepancy between TAC funding recommendations and the actual funds provided by the CGIAR. Also, some donors do not always meet the level of their original pledge commitments, and some tend to make their funds available on an irregular and unpredictable schedule. Such difficulties arising from donor funding arrangements have caused CIMMYT to experience serious cash-flow problems and have caused Programs to be curtailed or restricted unnecessarily, especially since the CGIAR provides only for limited carryover of funds.

B.43. This problem is illustrated in Figure B-3 which gives, for the core operating budget, the approved budget for CIMMYT for the years 1976-1983 in millions of dollars, along with the actual budget (reduced figures) which was available for spending.

B.44. The serious problems being experienced with inflation and reduction in constant dollars are illustrated in Figure B-4. Since 1979, CIMMYT has experienced a real decline in core funds.

B.45. Figure B-5 shows that the number of international staff levelled off or decreased during recent years. Also, it shows that the discrepancy in international staff needs for which funds have been approved by TAC and finally funded by CGIAR is growing. Furthermore, the financial crisis is causing serious curtailment in important activities. Major cost-saving measures have already been taken in operations. Further cutbacks, will, no doubt, seriously restrict the ability of CIMMYT to respond with the research and training considered necessary to meet the food producing demands of the developing world.

Figure B3



SOURCE: CIMMYT BUDGET DOCUMENTS

## 7.2 Allocation of Funds

B.46. The last available report on CIMMYT's actual expenditure of core funds was for the 1981 operating year. The utilization of the operating cost allocation of \$18,283,000 is shown below for the major categories of the budget.

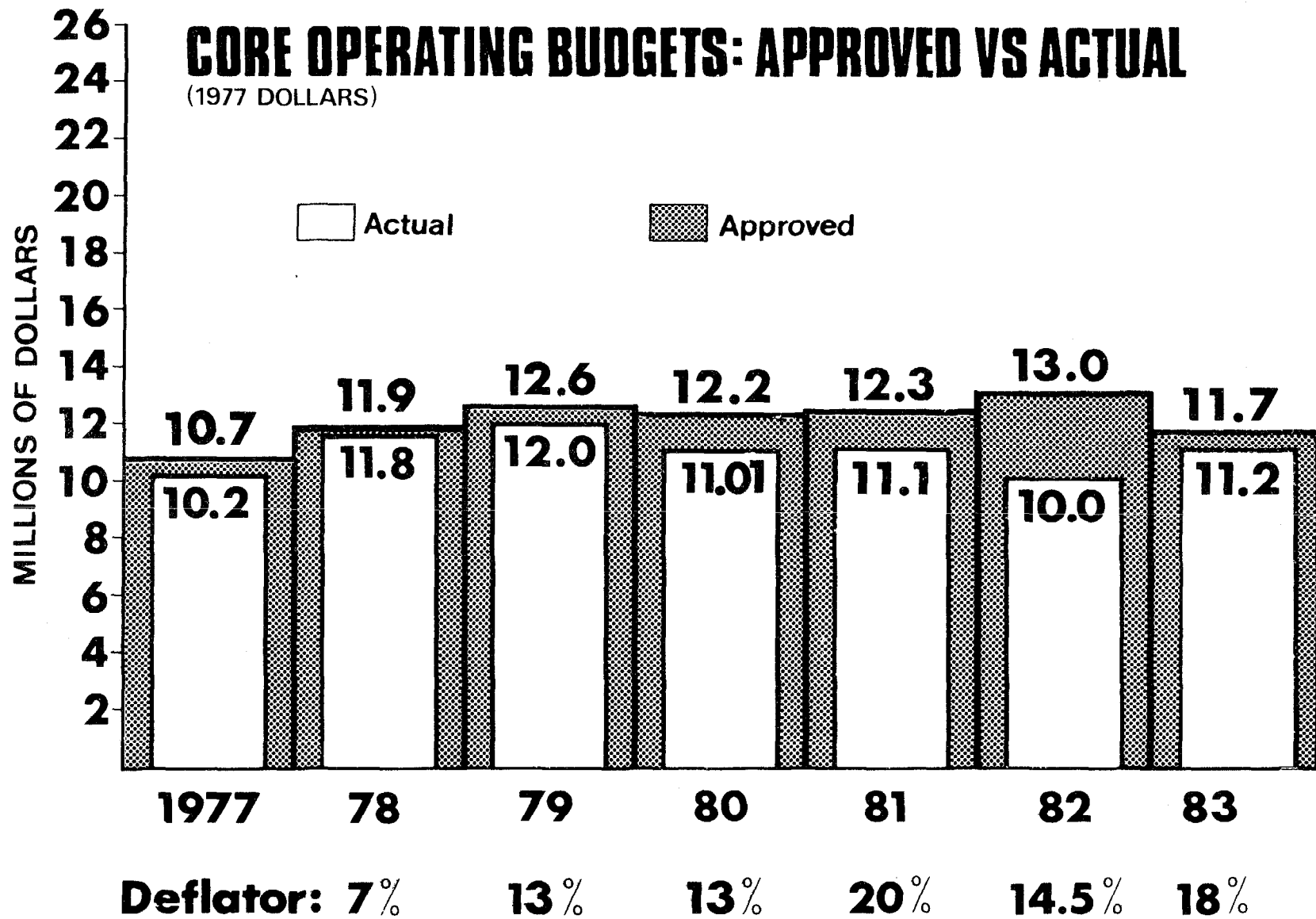
### The allocation of funds (operating costs) for CIMMYT for 1981

<u>Funding Categories</u>	<u>Thousand dollars</u>
Research	
Wheat	4,510
Maize	3,400
Economics	858
Research supporting services	3,028
Training & conferences	1,943
Information Services	691
General Administration	1,821
Plant operations	<u>2,032</u>
TOTAL	18,283

## 7.3 Priority Setting, Program Formulation and Resource Allocation

B.47. In response to specific questions raised for the consideration of the review Panel (Annex II), CIMMYT made an elaborate presentation of its mechanisms for setting priorities in the framework of its mandate

Figure L4

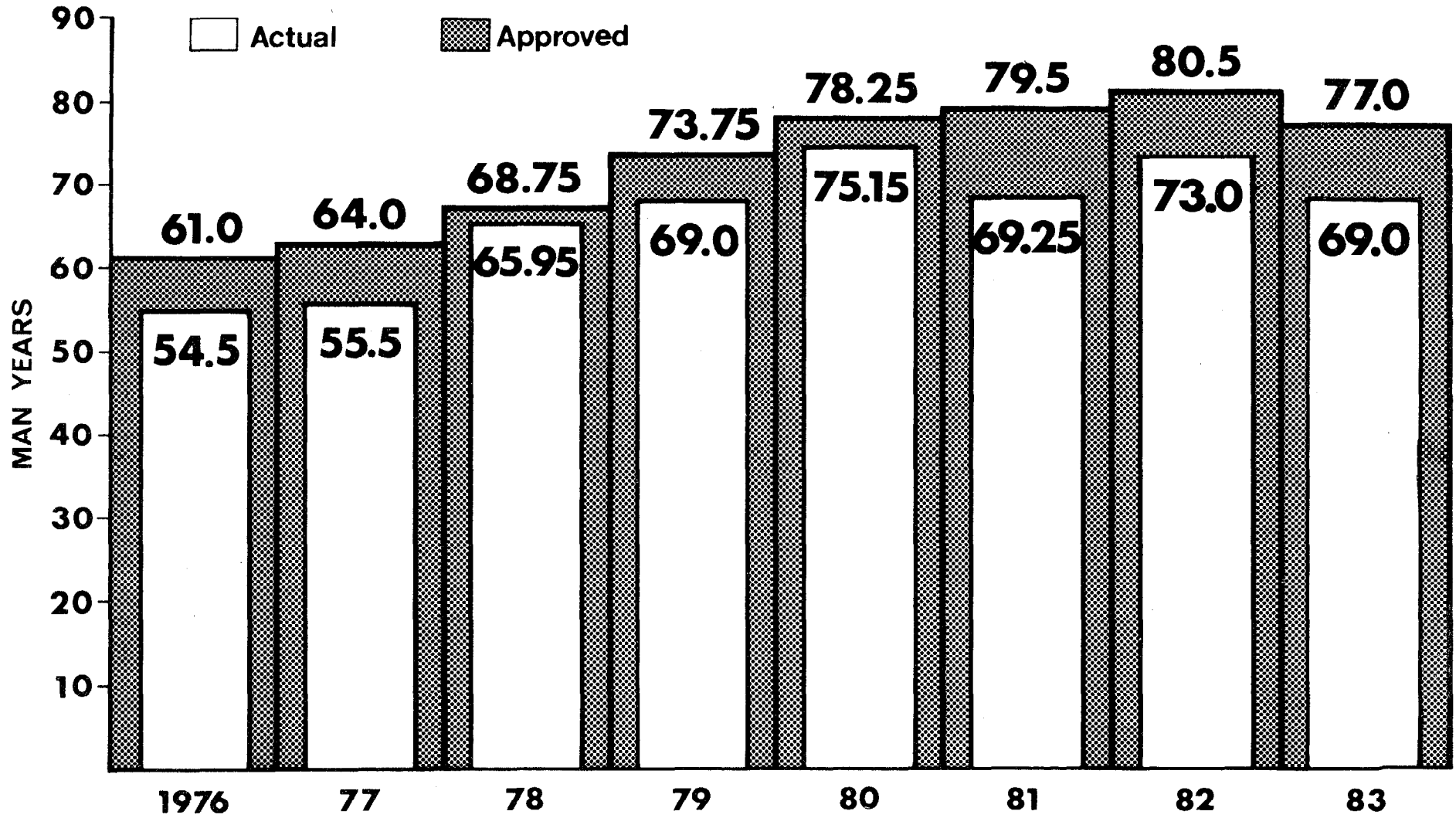


SOURCE: CIMMYT BUDGET DOCUMENTS

Figure B5

# INTERNATIONAL STAFF MAN-YEARS

## CORE OPERATING BUDGETS: APPROVED VS ACTUAL



SOURCE: CIMNYT BUDGET DOCUMENTS



and its strategies, and in the context of a review of its historical development.<sup>1/</sup> From this presentation and further discussion, the Panel concluded that the process used by CIMMYT in setting priorities is basically similar to those of other Centers and involves the governing body of the Center, internal and external reviews, planning conferences and workshops, and consultations with collaborating scientists and research leaders. Five major planning efforts were undertaken by CIMMYT in 1966, 1970, 1973-74, 1976 (for the first quinquennial review), and 1979-80 when CIMMYT developed a long-term plan titled "CIMMYT Looks Ahead--A Planning Report for the 1980s". (This latter document is discussed further in Chapter I.)

B.48. The Panel noted that the Board of Trustees relies essentially on the reviews of its Program Committee in monitoring the progress and the results of priority-setting and programming carried out by the Management of the Center. The Program Committee has played a growing role during the last few years as the problems of priority-setting became more acute with growing financial stringency. The Program Committee requested presentations (not only in the field but also in its meetings) of specific elements of the program and more detailed documentation. While the Director General's program proposals were generally endorsed, it is the understanding of the Panel that the Committee's scrutiny of the programs went into more depth and its observations and recommendations, although not formally recorded nor endorsed in the Board minutes, were followed up by Management.

B.49. The Panel noted that CIMMYT's Board has set criteria for the development of Regional Programs and the undertaking of special projects. Geographic priorities are set on the basis of several considerations, such as the importance of the production of the mandated crops of CIMMYT (in terms of area and tonnage), the population size and demands, the possibility of effective impact, and so on. As CIMMYT has recently made an analysis of statistics and trends for both maize and

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<sup>1/</sup> "Establishing Program Priorities at CIMMYT". Paper prepared for the 1982 Quinquennial Review Team, CIMMYT, August 31, 1982.

wheat by country and by regions, the Center now has the possibility to substantiate further its priorities which have so far been mainly based on judgements from expertise available within CIMMYT and externally. In fact, during the course of the review, CIMMYT indicated clear priorities among its programs for different regions (see Chapters C, D and E) which supplement the justifications given in its 1979 CIMMYT Review for the development of its Regional Programs.

B.50. As regards the formulation of the program and budget, the Panel was given a detailed description of CIMMYT's programs and subprograms, especially prepared for the quinquennial review, indicating for each subprogram the objectives, accomplishments, program content and future plans. The Panel wishes to commend CIMMYT for the major effort of detailed programming undertaken on the occasion of the second quinquennial review. While realizing that this detailed exercise may not be undertaken each year, the Panel notes that the "Budget Request of CIMMYT for 1983-84" would be improved by providing more details on the program contents so as to constitute an integrated program and budget document against which the CGIAR and TAC may assess program changes, achievements and related resource expenditures.

B.51. All directing staff are involved in priority-setting and the allocation of funds. However, the major decisions are made by the Director General in consultation with Program Directors and the two Deputy Directors General.

B.52. It is expected that the pattern of present allocation of core funds will probably continue for the immediate and foreseeable future. These allocations are:

	<u>Core</u>
Research	64%
Training	14%
Other	22%
Administration	9%
Physical Plant Opern.	10%
Information Services	3%

B.53. The distribution of the core funding for the Maize, Wheat and Economics Programs from 1976 through 1983 is shown in Figure B 6. Also, Figure B7 shows the distribution of core manpower among the three Programs. Table B1 shows the allocation of international staff across the Center as of 1982.

B.54. The Panel is cognizant of the serious financial crisis being experienced by CIMMYT. It commends the efforts that have been made internally to adjust to these conditions with an apparent minimum of disruption to activities. However, continued decreases in the budget cannot continue without serious damage to CIMMYT programs and staff morale.

#### 7.4 Auditing

B.55. Two principal audits occur: an internal accounting and an external auditing. The internal auditor operates on a daily basis under the supervision of the Deputy Director and Treasurer. However, he is responsible to and has final responsibility for reporting to the Director General. The Panel considers this operating procedure to be appropriate and correct. In presenting their annual report, the external auditors meet with the Executive and Finance Committee of the Board of Trustees.

Figure B6

# DISTRIBUTION OF CORE RESEARCH PROGRAMS

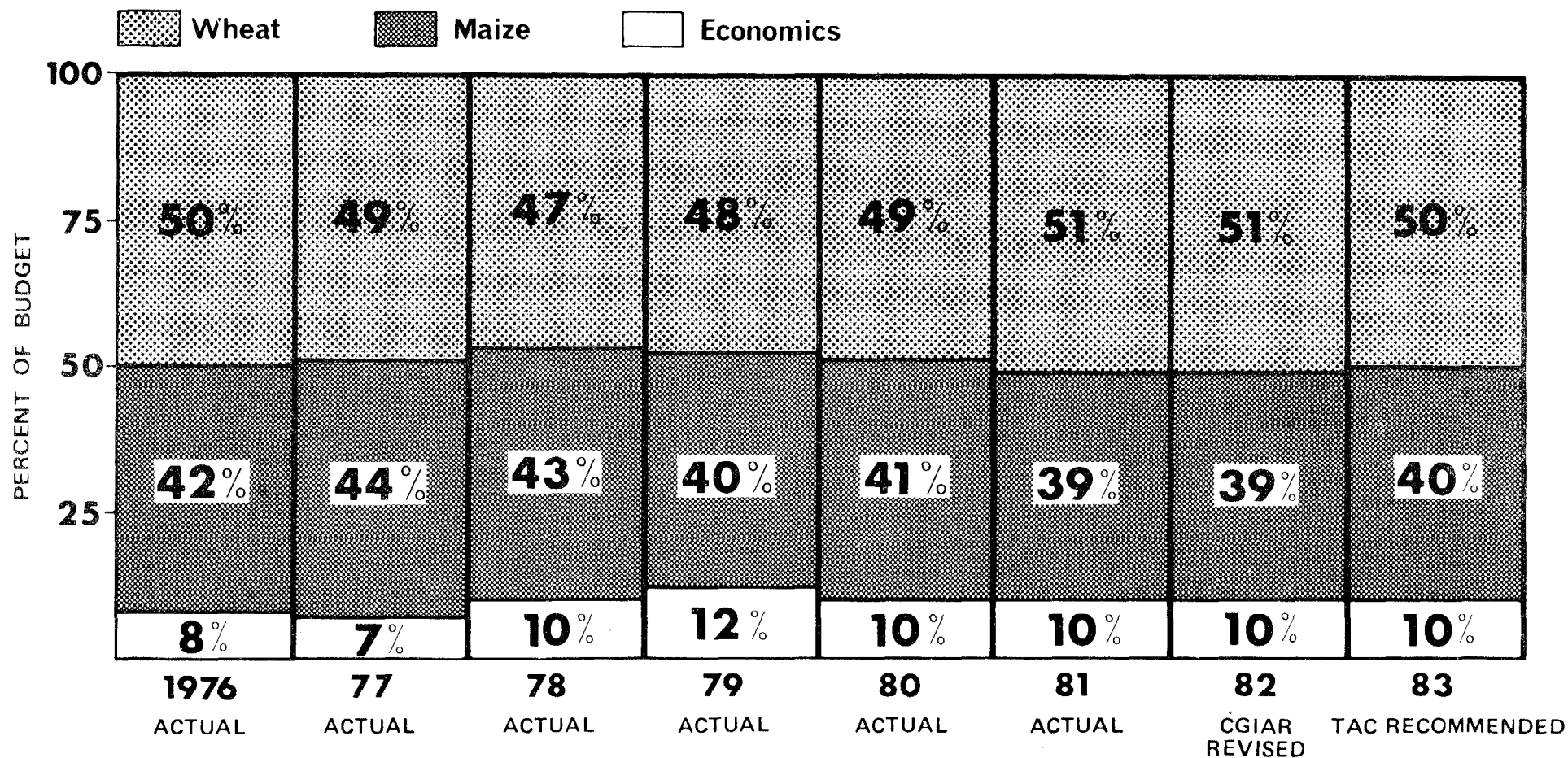
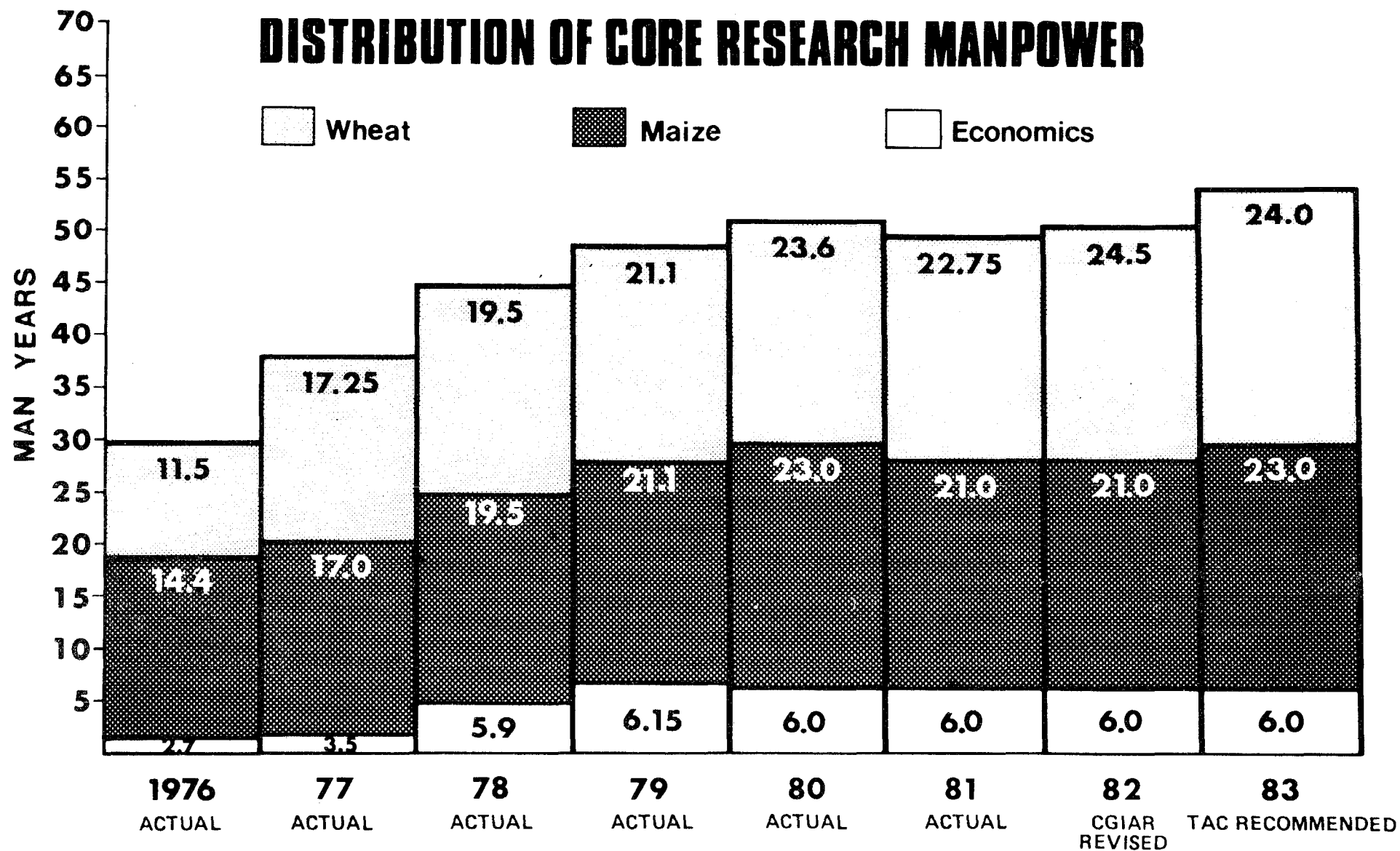


Figure B7



SOURCE: CIMMYT BUDGET DOCUMENTS

Table B 1. International Staff Allocation as of 1 April, 1982

	Head- quarters	Regional Programs	National Projects	Core Unrestricted	Core Restricted	Extra Core
Office of the Director						
General	4			4		
Wheat Program	19	9	2	22	5	3
Maize Program	12	11	3	12	11	3
Economics Program	4	4		5	3	
Laboratories, Data Processing	3			3		
Experimental Stations	3			3		
Information Serv., Admin.	4			4		
Total	49	24	5	53	19	6

## CHAPTER C

WHEAT PROGRAM1. Historical Background

C.1. The Wheat Program is a multi-crop program including subprograms on (1) bread wheat (Triticum aestivum) which is used as leavened bread and as unleavened flat breads, biscuits, cakes, and noodles, (2) durum wheat (Triticum turgidum), used for semolina products, such as spaghetti and bread-like products, (3) triticale (X Triticosecale), a stabilized wheat by rye hybrid, being developed for human food and animal feed uses, and (4) barley (Hordeum vulgare), for food uses.

C.2. The program is a direct outgrowth of a wheat improvement project started in Mexico by the Mexican Government's Office of Special Studies and the US-based Rockefeller Foundation in 1943. Norman Borlaug was posted in Mexico in 1944. His program focused heavily on breeding disease resistant varieties for use in Mexico. During the course of this program several other scientists were posted in Mexico on wheat improvement by the Rockefeller Foundation. Two of these as examples, John Gihler and Joseph Rupert, subsequently established similar programs in other countries under Rockefeller Foundation and government cooperation. Colombia, Ecuador, and Chile developed good programs under their direction and important advances in wheat production were made. CIMMYT today continues this basic modus operandi for in-country wheat improvement, with the important additional element that extensive amounts of germplasm are distributed from the headquarters operations in Mexico. Early in the program (1945), young scientists from various developing countries were invited to Mexico for training in wheat breeding. The early training programs emphasized breeding, but practical procedures in plant pathology and crop management were also introduced.

C.3. The Mexican program was highly successful locally in developing new varieties. Thirty or more varieties were developed and distributed by 1960. The continuous need for new varieties was mandated by rapidly

changing pathogen populations (primarily rust diseases) which were virulent on the new varieties.

C.4. Borlaug received some short-statured winter wheats from Orville Vogel in the USA. The Vogel lines were immediately hybridized to the tall disease-resistant varieties developed in Mexico. By 1958 some new short-statured spring wheats had been obtained. These materials raised hopes for improving winter-planted spring wheats just as Vogel and others before him in Japan had done with winter wheats. Borlaug advanced the breeding and selection of these wheats and released, with the Mexican government, the first short-statured spring wheats for use in the winter season of the Yaqui Valley in Sonora, Mexico, in 1962 (varieties Pitic 62 and Penjamo 62). These varieties immediately showed increased yields over the old varieties under irrigation and with higher amounts of nitrogen fertilization. With the rapid advance in agronomic characteristics, many new varieties were produced, with steadily increasing realized yields.

C.5. While disease resistance and short-stature dominated the goals and activities of the Rockefeller wheat program in those pre-CIMMYT years, a second achievement was realized. This was the "automatic" development of broadly adapted wheats by alternating the crop cycle from northern Mexico in the winter to a summer crop at high elevation in southern Mexico in the summer. Both environments favored wheats that were not day-length responsive. Thus, Borlaug selected so-called photoperiod insensitive wheats similar to those that had naturally evolved in the wheat production areas with relatively warm winters (Indian subcontinent, Mediterranean area, Australia, parts of U.S. and elsewhere). These high-yielding wheats were therefore ready-made for vast areas of the world's wheat-growing areas. The introduction of certain of these wheats to India and Pakistan, along with the ideas about maximizing their productivity, resulted in the so-called Green Revolution of the late 1960s.

C.6. These events had great impact on CIMMYT, which was formed in 1966 in the midst of these exciting developments. It showed that an



institution could focus internationally on a single crop and expect to be successful. Its success was dependent upon receptive National Programs. This already had been established among many National Programs through bilateral projects (of the Rockefeller Foundation and others) on cereals and other crops. The CIMMYT Wheat Program expanded its interests to specific problems (mainly diseases) in production deficient areas. The training role was expanded to include more trainees, broader discipline coverage (agronomy, plant pathology, and cereal technology), and levels of training (technology for post first-degree level and more sophisticated research for visiting scientists).

C.7. Finally, the scope of the Wheat Program was expanded to include durum wheat, triticale and barley in addition to bread wheats.

C.8. The short-statured durums had been under development in Mexico since the early 1960s but only a minimal effort had been expended. Great improvement of durums appeared to be possible for large areas in developing countries that have been traditional durum producers. These were mainly rainfed areas so the breeding objectives for durum may be somewhat different than for bread wheats.

C.9. Triticale was the third entry into the CIMMYT Wheat Program. It was based on observations of triticale in Canada in 1958 by Borlaug and Rupert. Subsequently, a Rockefeller Foundation grant was made to the University of Manitoba. In this cooperative program, just before CIMMYT was chartered, winter plantings were made in the Yaqui Valley by B.C. Jenkins, the Canadian scientist involved. In these plantings several very exciting triticales were found. These became the genetic materials for an extensive triticale development program started formally by CIMMYT in 1968.

C.10. Barley was also an obvious and important food grain component in the targeted developing countries. In 1972 CIMMYT initiated an improvement program with main emphasis on barley for food (excluding barley for feed and beermaking). Improved protein quality and content were the main goals along with increased yield and disease resistance. World germplasm

was called upon to start this program. Varieties from Mediterranean-type climates formed the basic germplasm, with European and North American germplasm providing disease resistance and other characters. Considerable effort has been given to developing free-threshing barleys. These so-called naked or hulless barleys may be more acceptable as a food than the hulled or covered types.

C.11. With the expansion of the scope of the germplasm development programs, there was a need recognized by CIMMYT to explore agronomic requirements for increasing productivity. A crop physiology program was conducted for five years which provided basic information for agronomic and breeding approaches. CIMMYT also recognized a need for expanding the germplasm base and has contributed by its work on intra- and interspecific hybridization.

C.12. It also became obvious that better definition of the quality characteristics of CIMMYT-derived wheats was needed and a quality evaluation laboratory was established.

C.13. The Wheat Program expanded to organize regional offices which now give attention to almost all of the world's developing countries where wheat is grown or has some possibility for local production.

C.14. An organizational view of CIMMYT's Wheat Program recognizes germplasm as the focal point with disciplinary contributions to its development. CIMMYT's products are improved germplasm, trained scientists and technologists, and information services to food-deficient and in some cases food-exporting countries.

## 2. General Objectives

C.15. The Wheat Program contributes to CIMMYT's goal for increasing world food production in a multidisciplinary manner. Its basic premise is that seed is the focal point in cereal production. Thus improvement of crops by genetic means has been the central goal of the program. Its objectives are to develop and distribute improved germplasm (seeds) of

wheat, barley and triticales to National Programs in developing countries and to organizations which are contributing to world food production in developed countries. Further, to ensure that improved varieties are multiplied, distributed and adopted, the Wheat Program endeavors to train National Program scientists and technical staff who can provide impetus and continuity to National Programs.

C.16. Adoption of varieties depends upon proper crop management practices which may be improved upon or modified drastically in the course of improving crop production. Research on and demonstration of agronomic and pest management practices is the means by which CIMMYT's crop production improvement goals are met in the Wheat Program.

### 3. General Structure and Content of the Program

C.17. Although designated the "Wheat Program", the work of this division encompasses four crops. These are bread wheat, durum wheat, triticales and barley. The breeding procedures used in these crops are very similar, so similar that they have been dealt with together in this chapter. The descriptions therefore apply to all four crops unless otherwise specified.

#### 3.1 Germplasm Bank

C.18. The CIMMYT Wheat Program has developed and distributed thousands of breeding lines in the past 16 years. Many of these lines are used in the CIMMYT program as breeding materials, thus perpetuating the desirable genes and gene combinations. It is also important that the materials with good characteristics, which will not be released as varieties, be retained for future use in breeding. In other cases, a particular breeding line may have disease resistance that was not needed at the time of its development, but subsequently found useful. Such materials should be stored in a germplasm bank so that it may be recovered at any moment. The largest collection of triticales in the world exists in the CIMMYT Wheat Program Germplasm Bank and CIMMYT has accepted responsibility for maintenance of this collection.

C.19. CIMMYT has retained viable seed of varieties and breeding lines that were widely used in breeding since 1969. However, inadequate seed storage and the relative inaccessibility of breeding materials resulted in a change of attitude toward the germplasm collection and a new germplasm bank was constructed with funds donated by the Government of Japan. A curator was retained in 1981.

C.20. The germplasm bank will include advanced lines and special sources of bread and durum wheat, triticale, and barley that are or have been used in the CIMMYT breeding programs. It has a present capacity of 90,000 items. It will be a working collection from which seed will be distributed to CIMMYT scientists and cooperators.

C.21. Description and limited evaluation of the materials will be done by the curator. All information about each item will be readily accessible through a computer-based data management system when the bank is fully operational. Seed stocks will be multiplied as needed at a CIMMYT research station.

C.22. Small samples will be sent to the USDA National Seed Storage Laboratory (NSSL) at Ft. Collins, Colorado for permanent storage in its base (nonworking) collection. NSSL will monitor the seed viability and will arrange for seed multiplication by CIMMYT when needed.

### 3.2 Wide Crosses

C.23. There is great interest among breeders in obtaining novel sources of variability by any means. Usually this is facilitated from world collections of the crop species. Related species (both wild and domesticated) also provide a source of variability. Wheat, and barley to a lesser extent, can be hybridized with many of their related species.

C.24. CIMMYT has had collaborative exploratory research in such a "wide cross" program. The goals in that program were to make wheat x barley, wheat x oats, and other novel (and difficult) hybrids. This program had only minimal success and was discontinued.

C.25. In 1979 a cytogeneticist was appointed for wide cross work at CIMMYT. Most attention is being given to wheat x Elymus giganteus and wheat x Agropyron distichum hybrids, but a few others are in progress. The Elymus and Agropyron species have resistance to several wheat diseases and apparent resistance to some factors important in stress resistance, such as drought, heat, and salinity. After these hybrids are made, standard cytogenetic techniques are used to transfer individual chromosomes and, later, small segments of a chromosome to wheat chromosomes. At this stage the materials will be available to the breeders through the germplasm development unit.

### 3.3 Germplasm Development

C.26. The Wheat Program has one staff member specifically assigned to a unit called germplasm development (GPD). This activity is also known as "prebreeding" or "germplasm enhancement." For the most part, this work has focused on intraspecific variation (i.e. variation within wheat, triticale or barley). When the wide cross program, discussed above, produces intergeneric derivatives, the materials may be transferred to the GPD for further development before use in the breeding program. The wide cross and GPD programs provide a logical flow of germplasm to the breeding program. In principle, they are essential elements of a modern cereal improvement program.

C.27. The GPD program also involves some interspecific gene transfer within Triticum. Aside from those applications, gene transfers within the bread and durum wheats and barley are in progress. Standard methods of hybridizing, backcrossing and selection are used.

C.28. The specific objectives of the GPD program include, but are not restricted to, the following: (1) developing new morphological variants of wheat, including branched spikes, large seeds, large or small leaves, solid stem and others, (2) developing isolines of prototype varieties, such as various height types, and specific disease resistance genes, (3) improving protein content of bread wheats, (4) improving aluminum (low soil pH) tolerant bread wheats, and (5) improving rye for further use in

triticale development. Each year some specific programs are completed and the materials transferred to the breeding program and distributed to cooperators. Likewise, new projects are initiated in response to requests from plant breeders. Most recently, resistances to Fusarium scab, Helminthosporium sativum, and H. tritici -repentis have been identified as a great need in the breeding programs for the Asian region.

### 3.4 Breeding Programs

C.29. The general aim is to produce varieties that have high and dependable yielding ability and are broadly adapted. Many characteristics must be considered to produce such varieties. Table C1 summarizes some of the most important ones. The diseases that are important vary with the crops and the regions, but resistance is sought for the various rusts, the Septoria species, Helminthosporium species, scab, barley yellow dwarf virus and scald. Triticale is far less affected by diseases than the others, but this may change once it is grown widely.

Table C1. Major selection criteria (X) for the four crops

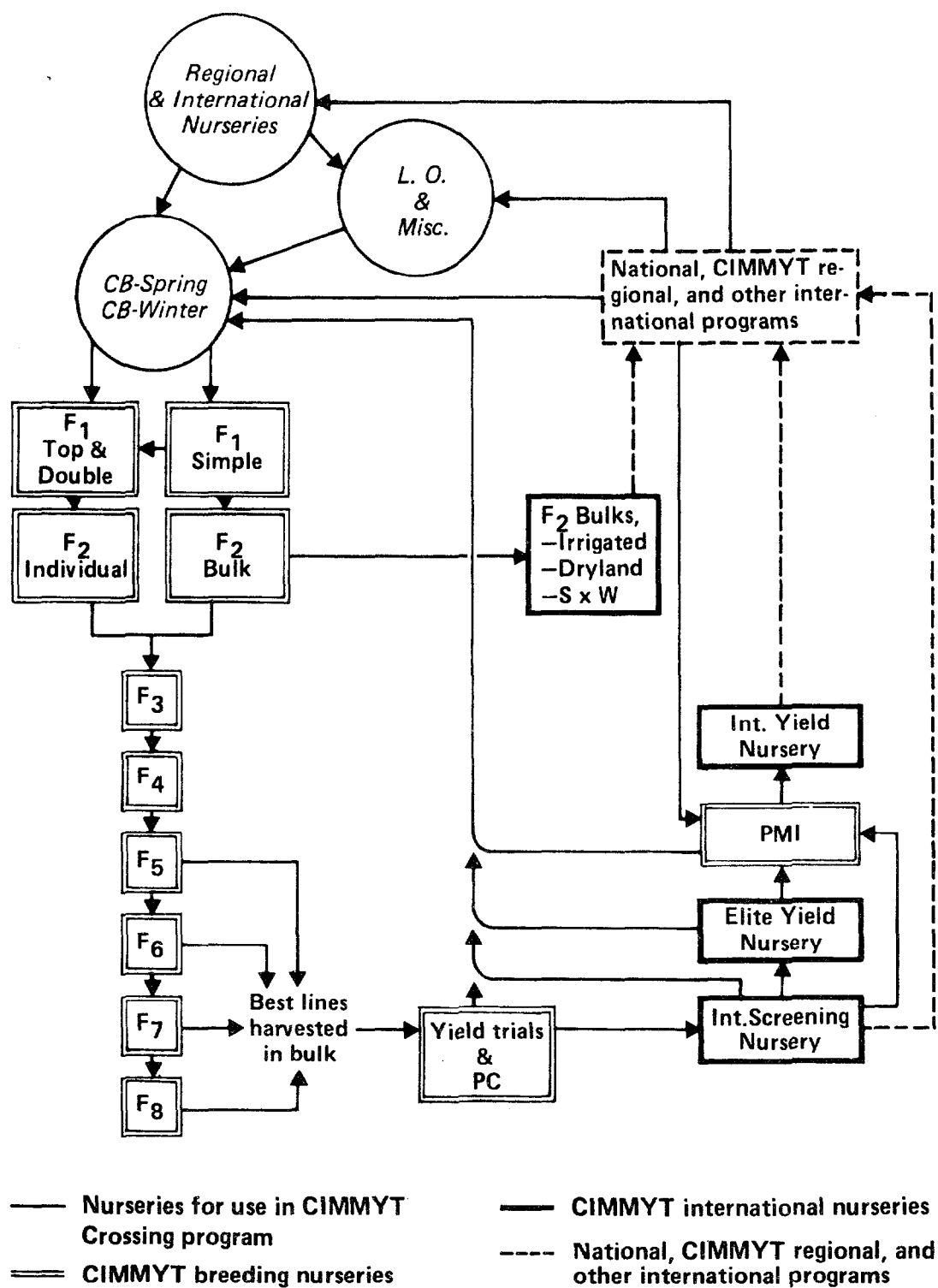
Characteristic to be improved	Bread Wheat	Durum wheat	Triticale	Barley
Resistance to various diseases	XX	XX	X	XX
Tolerance to drought	X	X	X	X
Tolerance to heat	X			
Tolerance to cold		X		X
Tolerance to Al	X			
Quality for processing	X	X	X	
Maturity, esp. earliness	X	X	X	X
Length of straw, esp. shorter	X	X	X	X
Test weight		X	XX	
Nutritional quality				X

C.30. Selection of improved varieties for processing (for bread, cookies, biscuits, tortillas--bread wheat and triticale--and for spaghetti, couscous, semolina--durum wheat) is done continuously. Earliness and shorter straw are especially sought. Early varieties fit better in the yearly rotation cycle with rice in the Asian region and escape high temperature and moisture limitations in other wheat and barley growing areas.

C.31. Varieties that carry some of the required characteristics are brought together in crossing blocks (CB). In these CBs large numbers of crosses are made each season between varieties with complementary characteristics. The F<sub>1</sub>s obtained are grown the next season and, in order to combine even more characteristics, F<sub>1</sub>s are combined into double crosses or are crossed to a third variety (topcross). Selection is practiced on the F<sub>1</sub>s, resulting in 30-75% of the crosses being discarded. The F<sub>2</sub> seeds harvested from the F<sub>1</sub>s are sown widely spaced and the best plants are selected for disease resistance, tillering capacity, head fertility, shortness of straw, maturity, etc. Thereafter, a pedigree selection procedure is followed, i.e., in the F<sub>3</sub>s, F<sub>4</sub>s, and F<sub>5</sub>s the best plants of the best lines are selected. As soon as a line is uniform and good for the above-mentioned characteristics, it is harvested in bulk, usually in the F<sub>5</sub>, F<sub>6</sub>, or F<sub>7</sub>. These advanced lines are yield-tested at the INIA station (CIANO) in northern Mexico and to a limited extent at CIMMYT stations at El Batan and Toluca. Recently; however, CIMMYT has started to send all advanced lines (some 1500 in bread wheat, some 700 in durum wheat) to its regional breeders who observe them in their regions. The best advanced lines from these CIMMYT yield trials enter the international screening nurseries. The best lines from these nurseries are advanced to the yield nurseries as described in C3.5 (see Figure C1).

C.32. To carry out this breeding program up to the international testing stage, three locations are used within Mexico: Ciudad Obregon (CIANO) in the Northwest (29° latitude, 40m altitude), El Batan (19°, 2240m) and

Figure C1. Movement of Germplasm in CIMMYT's Wheat, Triticale, and Barley Programs.





Toluca (19°, 2640m) in the Central Highlands. Resistance to specific diseases is also evaluated at other sites. These locations allow two generations of crops to be grown and tested each year, the first during the winter at Cd. Obregon and the second during the summer at the highland locations. The production of F<sub>1</sub>s (crossing) and the testing of the various generations (F<sub>2</sub> to yield testing of advanced lines) are done at all three locations. This system has three important advantages:

- (i) The breeding process is rapid because of two crops per year.
- (ii) Selection is carried out under very different conditions favouring the selection of broadly adapted genotypes.
- (iii) The breeding materials are exposed to a spectra of diseases.

C.33. The advanced lines that pass the selection stages in Mexico enter the international testing program. This testing, done at a great number of locations across the world, representing the whole range of possible wheat growing conditions, enhances the selection of varieties with a broad adaptability and resistance to a wide range of pathogens and their biotypes.

C.34. The national research organizations evaluating the entries in the international nurseries in their country may choose advanced lines to be used in their own breeding programs and/or for use as varieties in their area.

C.35. The locations in Mexico, however, do not represent all the world's important wheat-growing areas. For such diseases or environmental conditions not occurring at the Mexican locations, other locations have been sought either within or outside Mexico. Selection for scab resistance, for instance, has to be done in cooperation with scientists working in "hot spots" for this disease. Cooperation with China is in the offing with this aim. Tolerance to aluminum toxicity, a problem on acid soils, is a serious problem in Brazil and elsewhere. Cooperation with Brazilian scientists using "shuttle breeding" has been successful in getting rapid progress in breeding aluminum or low pH tolerant wheats. Tolerance to drought and heat is also sought. The development of heat-tolerant bread wheats forms a special project to obtain wheat

varieties which can be grown in dry, hot climates or in dry, humid climates.

C.36. The selection results depend both upon the quality of selection and the genetic contents of the population to be selected. The latter depends to a very large extent on the parents chosen for the crosses. Selection of the parents is based on results from the various regional and international nurseries, including non-CIMMYT organized nurseries, and from miscellaneous nurseries. Cultivars and lines received by CIMMYT from outside sources are evaluated first in the Observation Line Nursery (OL) and promising ones are re-evaluated in the Miscellaneous Nursery (Misc.) prior to entry into the CB. Parents also come from the Germplasm Development Program (see section 3.3 above).

C.37. To increase the yield potential of spring bread wheats, the gene pools of spring (S) and winter (W) wheats have been combined. Each year a large number of such SxW crosses are made and many of such F<sub>1</sub>s are either backcrossed to spring wheats or to other SxW wheats. A group of selections named Veery is a result of this program. These selections have shown outstanding performance in worldwide testing and are being widely adopted in many National Programs. This work is done in cooperation with Oregon State University, where the emphasis is placed on winter wheats.

C.38. With barley, similar SxW crosses have been made. In addition, beside the hulled or normal barley, hullless (naked) barley varieties are produced as they are assumed to be more suitable as a human food source. Nutritional improvement in barley is also sought by increasing the lysine content of the grain. High-lysine genotypes with good endosperm characteristics have been recovered but they need further improvement in yielding ability and disease resistance.

### 3.5 International Testing

C.39. The major objectives of international testing are to provide superior germplasm to the collaborators in National Programs and to

collect data regarding adaptation and other characteristics that cannot be obtained from the Mexican locations. These and more specific objectives are provided through a series of International Nurseries, each nursery consisting of entries (lines or populations) that are sent to those cooperators in National Programs who request them.

C.40. The nurseries that aim at providing the national collaborators with superior germplasm consist of four types: Crossing Blocks, the F2 nurseries, the screening nurseries and the yield trials.

C.41. Crossing blocks (CB). Each CB consists of up to several hundred carefully selected lines of potential parents for use by National Programs. The lines are classified for grain type, milling and baking quality, resistance to specific diseases, yield potential, agronomic type, etc. The collaborator can select from these lines for the local breeding program. Only collaborators with breeding expertise and facilities receive these CBs.

C.42. F2 International nurseries. The F2 nurseries are designed for particular environmental conditions. For example, in bread wheat there are F2 nurseries for irrigated conditions, for rainfed conditions, for tolerance to aluminum and for areas where facultative wheats (spring wheats with greater cold tolerance) are needed. National Program breeders carry out their own selection programs with F2 populations.

C.43. Screening nurseries. The advanced lines that pass the selection process in Mexico enter the four international screening nurseries, one in each of the four crops. The number of entries per nursery varies from 200 in durum wheat to over 400 in bread wheat. The number of locations to which they are sent varies from about 100 for barley to about 200 for bread wheat. The advanced lines are compared with one another and local varieties in small plots.

C.44. There are also a number of international disease nurseries designed to identify and evaluate potential sources of resistance to Septoria, powdery mildew, Helminthosporium and other diseases. CIMMYT

selects the participating locations on the basis of the likely occurrence of the disease.

C.45. Yield nurseries. The very best advanced lines based on evaluation are Mexico and elsewhere included in the International Yield Nurseries (25 to 50 entries). There are two Elite Yield Nurseries for spring bread wheat and durum wheat (the wheats are tested in two stages), and five International Yield Nurseries for spring bread wheat, durum wheat, triticale, naked barley, and hulled barley. The International Yield Nurseries also contain, besides the CIMMYT entries, promising cultivars from other programs and a local variety.

C.46. From the screening as well as the yield nurseries, the collaborators are encouraged to select lines to use in their own breeding programs. National Programs can release lines that performed best in the yield trials as varieties. This is always a responsibility of the national governments since CIMMYT does not release varieties.

C.47. All these nurseries have in principle a world-wide distribution. There are also a number of nurseries issued by CIMMYT's regional programs.

### 3.6 Regional Programs and Bilateral Programs

C.48. To improve the links with National Programs and to stimulate the distribution and evaluation of CIMMYT germplasm, regional programs have been initiated (see also Chapter G, section 2.1). Other objectives of such regional programs as stated by CIMMYT are to:

- Encourage and support production agronomy research and help in the establishment of on-farm research programs.
- Improve and coordinate training opportunities within and outside the region.
- Organize workshops and field tours for regional scientists.
- Identify problems and coordinate visits for CIMMYT and other scientists to the region for consultation assistance.

- Carry out specific research activities of benefit to the world-wide network for which a region is particularly well-suited to carry out such research.

C.49. The regional programs are a fairly recent extension of the CIMMYT program, the first one dating from 1973. In 1977 there were three regions in operation. In 1981, there were seven: (1) Andean countries; (2) Southern Cone of Latin America; (3) North and West Africa and Iberian Peninsula; (4) Eastern and Southern Africa; (5) South and Southeast Asia; (6) Near East, located at ICARDA; and (7) Disease surveillance.

C.50. The activities within any region vary with the countries, some making much better use of the regional programs than others. This depends on the strength of the National Program, the political situation and the potential importance of wheat, triticale and/or barley. Within the regions and even within countries, the environmental conditions to which the crops are exposed can vary tremendously.

C.51. The minimum effective level of staffing of a regional program has been considered by CIMMYT to be a breeder pathologist, an agronomist, and an economist (from the Economics Program). This, however, has not been realised, the regions being staffed with one or two CIMMYT staff members at present.

C.52. The program headquartered in Kenya has an important additional function. It is a hot spot for the cereal rusts and can therefore provide extra information, highly useful to the breeding programs at headquarters in Mexico. In Kenya each year some 20,000 entries are screened for rust resistance. The most promising lines enter the Screening Nursery for the African Cooperative Wheat Yield Trial (SNACWYT) and then the best 15 lines from this screening trial are entered into the African Cooperative Wheat Yield Trial (ACWYT). The East African Regional Program also assists the National Programs of North Africa and the Near East in the provision of a summer nursery (off-season for these countries) at Njoro, Kenya.

C.53. The regional program headquartered at ICARDA has its own bread-wheat breeding program for the region. In cooperation with ICARDA, CIMMYT has taken the full responsibility for bread wheat and triticale. This means that the breeding program for bread wheat at ICARDA has become the responsibility of the CIMMYT regional staff at ICARDA. This breeding program follows the same pattern as the CIMMYT program at the headquarters in Mexico. The segregating populations and advanced lines originate from CIMMYT, Mexico and ICARDA, and are evaluated in the ICARDA international bread wheat nurseries such as the Preliminary Observation Nursery, the Rainfed Wheat Yield Trial and the Regional Wheat Yield Trial.

C.54. The Disease Surveillance Program operates two nurseries in a joint activity with ICARDA. The Regional Disease and Insect Screening Nursery (RDISN) and the Regional Disease Trap Nursery (RDTN) are sent to collaborators in North Africa, the Middle East and parts of Asia. The former will be transferred into a new Elite Nursery (Global) in 1983. The entries in the RDTN consist of varieties that are grown in the region on about 100,000 ha or more. The information obtained from the field evaluations and from the race inventories for the three wheat rusts give an indication of the potential threat to the resistance of commercial varieties. The collaborators are asked to send rust samples to cooperators in the Netherlands, Egypt, and Yugoslavia.

C.55. The RDTN was started as a regional nursery, but has grown to involve 200 locations in 52 countries, thereby changing from a regional disease surveillance to a more global disease surveillance function.

C.56. The Andean Regional Program also organizes two regional nurseries, the Latin American Disease Screening Nursery (VEOLA) and the Latin American Disease Trap Nursery (ELAR), both distributed through Latin America and having similar objectives as the RDISN and the RDTN. The Southern Cone Regional Program has a regional nursery, Advanced Lines of the Southern Cone (LACOS), distributed over the countries of that region.

C.57. Although the major thrust of CIMMYT outside its headquarters is in the regional programs, it also has bilateral national projects. At present there are two such projects: one in Pakistan and the other in Bangladesh. The major objectives are to provide direct assistance to the national wheat programs and to work on a daily basis with national wheat program counterparts in all aspects of national wheat research, staff development and training.

### 3.7 Maintenance of Recommended Varieties and Seed Production

C.58. Varieties are released and recommended only by National Programs, thus the maintenance and multiplication of these varieties is a national responsibility. The national institutions that need to take care of the maintenance, multiplication and distribution of these varieties are often insufficiently developed. Fortunately, all four crops in CIMMYT's Wheat Program are self-pollinating, thereby ensuring the genetic identity to a fair extent even when such varieties spread from farmer to farmer.

C.59. CIMMYT retains a small sample of each released variety in its Germplasm Bank. This enables it to assist National Programs by ensuring availability of foundation seed stocks.

### 3.8 Pathology

C.60. The protection of crops through genetic resistance to disease is of the utmost importance and, to attain this, sophisticated methods are often needed. Pathologists are therefore needed in a large breeding program like this one. The objectives are to:

- Identify and develop cultivars with resistance to a broad spectrum of races of the adaptable pathogens.
- Identify and develop cultivars with resistance to important pathogens not yet known to generate new races easily.
- Explore other uses of resistance genes, such as multiline varieties, varietal mixtures, etc.

- Develop regional disease surveillance systems which can serve as early warning mechanisms in the major production areas of the developing world, and which in turn may allow for a more effective deployment of resistance genes.

C.61. Headquarters. The Wheat Program pathologists cooperate in a highly integrated way with the breeders in the various breeding programs, where (with the current exception of triticale) disease resistance is of the utmost importance. They produce, where necessary and possible, the required disease pressure from field collections of rust spores or of greenhouse or laboratory-reared inoculum of other diseases to ensure good discrimination between resistant and susceptible entries in the CIMMYT nurseries in Mexico. Race identification in some cereal rusts is carried out to indicate which races prevail in Mexico and which races should be used in the creation of artificial epidemics. Also, a large number of early generations are screened for resistance to several foliar diseases in the seedling stage in the greenhouse, the resistant ones being planted in the field for further evaluation and seed production. The pathologists also participate in the in-service training programs for National Program representatives.

C.62. Regional programs. The pathologists assist National Program scientists in screening germplasm for resistance to the locally important diseases. The disease surveillance nurseries (see section 3.6 above) are an important part of the regional work.

C.63. To decrease the dependability on unstable forms of resistance in the case of cereal rusts, selection has been carried out to identify advanced lines and cultivars that show slow rusting or that have a relatively stable low disease coefficient across locations. Both characteristics may indicate the presence of polygenic or more durable forms of resistance and ensure the selection of plants resistant to a broad spectrum of pathogenic races.



### 3.9 Milling and Baking Quality

C.64. Evaluation for milling and baking quality is carried out in the milling and baking laboratory at CIMMYT headquarters. The objectives of this quality assessment are to:

- Evaluate bread wheat and triticale for suitability in making bread, tortillas, chappatis and cookies, and durum wheat for its suitability to produce macaroni, semolina, couscous, etc.
- Investigate which mixtures of different flours (wheat, triticale, barley, maize) give good quality for bread-making.
- Offer training facilities and give advice when requested.

Virtually all advanced lines involved in the various international wheat and triticale nurseries are evaluated for their industrial qualities.

### 3.10 Agronomy

C.65. The Wheat Program includes an agronomy research subprogram which has three main activities: (1) in-service training to students and visiting scientists from developing countries, (2) nonsite-specific research at CIMMYT stations in Mexico, and (3) developing recommendations to support the breeding programs. Agronomists are located at headquarters and in regional programs. It has been CIMMYT practice to assign agronomists to regional programs after several years of training and research in Mexico.

C.66. CIMMYT agronomists assist the production training program (discussed below) through field and classroom activities. They provide advice and assistance on field trials that are designed for the training program by the Training Officer.

C.67. Weed control research has received considerable attention at CIMMYT's Mexican stations in which chemical and cultural practices for control of a wide range of weedy species are investigated. Various methods of herbicide application are examined, with conditions in developing countries in mind. Special attention is given to control of

weeds by crop rotation and other specific management systems to eliminate the need for using expensive and hazardous chemicals in developing countries.

C.68. Since much of the cereal producing areas are moisture-limited, research is under way to examine drought responses using various physiological parameters, such as leaf temperature. Interactions of seeding rates and fertilization inputs are examined in the context of rainfed crops.

C.69. Activities supporting the breeding program include identifying plant responses that may be useful to the breeders as selection criteria and analysis of soil problems that may have contributed to yield decline on experiment stations.

### 3.11 Training

C.70. In-service training was originally directed toward wheat breeding, but now includes courses in production agronomy, pathology, cereal technology, and experiment station management. The main goal of the training programs is to assist developing countries in improving their research and extension activities.

C.71. The CIMMYT Wheat Program provides training in several ways: (1) formal courses lasting for several months (usually 6 or 7), (2) individualized programs for visiting scientists for a few days to several weeks, (3) individualized research predoctoral programs in conjunction with a university professor, and (4) postdoctoral programs assigned to specific programs for up to 2-year appointments.

C.72. In the formal training courses the trainees gain extensive field experience and receive formal lectures and demonstrations from the Wheat Training Officer and the program staff scientists. Staff from the Economics Program participate in the agronomy production courses. Training is also arranged at the regional level through workshops, travelling seminars, and individualized instruction to local scientists.

C.73. The Panel was informed that training was a high priority activity in the Wheat Program.

### 3.12 Communications

C.74. While the CIMMYT Wheat Program is best known for distribution of germplasm, it also distributes many reports on the agronomic and disease reactions of breeding materials. Its role in communications extends far beyond such reports. Interpersonal communication through visits and correspondence provide a valuable means of transmitting scientific information. At the regional level, communication is extremely important because the regional representatives serve predominantly in an extension education role.

C.75. In the Wheat Program, international nursery reports and the annual reports on wheat improvement are the principal means of informing cooperators about new developments. The CIMMYT TODAY serial publication occasionally features a Wheat Program topic. Scientists occasionally present papers to professional society meetings and invited lectures at symposia. In the past, several valuable publications appeared in the CIMMYT bulletin Series, but these were discontinued. Peer-reviewed journals are also a source of publication of scientific results.

## 4. Means and Facilities

### 4.1 Staff and Other Personnel

C.76. The present number of Wheat Program staff are detailed in Table B1. Plant breeders are assigned to each of the crops and based at headquarters. One breeder is assigned to each of the four crops. Often a postdoctoral fellow is assigned to each crop program as well. The Panel regards this staffing pattern to be a minimum staff assignment for a Center with such a strong focus on germplasm development. Some of the regionally deployed staff can be recalled to headquarters if an emergency arises, but there would be a serious lack of continuity in such an event. Secondly, there is presently limited opportunity for the

staff to develop basic information on breeding methodology, genetics, or assessments of breeding progress. The Panel regards the headquarters plant breeding staff to be minimal, especially with only one breeder per crop. In fact, the Wheat Program can be viewed as vulnerable in plant breeding.

C.77. The breeding programs are well-staffed with plant pathologists and agronomists, but are presently understaffed in plant-soil-water relationships, an area CIMMYT regards as important since breeding for environmental stress resistance is a high priority activity.

C.78. Through mechanization of field operations it has been possible in the past to expand the program without a corresponding increase in staff and personnel. This tendency may continue, depending on the budget; with a stable or declining budget more mechanization may be needed to replace some personnel.

#### 4.2 Land and Equipment

C.79. The available equipment seems to fulfill the needs well. Only land at El Batán and Toluca is somewhat limiting. Although the present program can be accomplished at these two stations, the addition of more land would give useful flexibility.

#### 4.3 Budget

C.80. The present budget does not allow expansion of the program. This means that expansion of regional program staffing is not likely to occur. If this were to occur at the expense of the core program at headquarters, it would not be viewed by the Panel as an acceptable alternative. The Panel would favor redistribution of regional staff to high priority regions.

### 5. Achievements

C.81. The achievements should ultimately be judged in terms of impact on productivity of farmer's fields. This is very difficult to measure as

such but a good measure is of course the adoption by the farmer of CIMMYT's germplasm directly (as finished varieties) or indirectly (varieties locally bred with the aid of CIMMYT materials) through National Programs.

C.82. In the developing world over 35 million hectares are planted to varieties that carry CIMMYT-developed germplasm in their pedigrees. Most of the released varieties are bread wheat varieties (Table C2). The other three small grains have as yet made a smaller impact due to the fact that these programs started much later.

Table C2 Number of Varieties Recommended and Released by National Programs and Based on CIMMYT Germplasm, 1966-1981. (This list is probably not complete.)

Area	No. of Countries	Bread Wheat	Durum Wheat	Triticale	Barley
Africa	13	49	15	0	0
Near East	8	24	5	0	2
Asia	6	61	4	0	1
Latin America	7	60	8	5	2
East Europe /Iberia	6	16	4	12	0
Developed Countries	7	43	2	19	0
Total	47	253	38	36	5

C.83. Another major achievement, not yet fully realized, is found in the triticale program. Triticales developed in the past five years have produced gain yields equal to or better than those of the best wheats. This is a real breakthrough as only 15 years ago the best triticales yielded only some 40 percent of the best wheats. These and other data suggest that a further increase in yield beyond those of the wheats is possible.

C.84. The durum wheat and barley programs, although fairly young, have already produced their first varieties. Based on the same breeding

program as in bread wheat, one may hope that a similar impact will be achieved with these two crops in the future.

C.85. Other achievements include: (1) improvement on already successful breeding procedures; and (2) the recombination of the spring and winter gene pools in bread wheat, durum wheat and barley which has greatly enlarged the genetic variation for selection. Clear successes already have been made in bread wheat varieties that are slightly higher yielding, have good disease resistance and high tolerance to agroclimatic stresses.

C.86. As far as training is concerned, about 630 trainees have completed the formal courses in the Wheat Program. Rainfed agronomy and breeding have had the largest enrollments.

## 6. Constraints

C.87. Apart from budgetary and political constraints, no clear limiting factors seem to be present, although soil problems at the test locations in Mexico may become a problem in the future as well as irrigation at El Batán.

C.88. Another constraint is the vulnerability of each of the breeding subprograms carried out by one headquarters staff member only. If that could be done by two staff members, the breeding, travelling, training and research aspects could be shared and additional research functions could be assumed.

## 7. Future Plans

C.89. In "CIMMYT Looks Ahead--a Planning Report for the 1980s," written in 1980, there was still the idea of growth in the Program. In such a case, planning is not all too difficult. Thus, the wheat program was expected to grow from 31 to 38 senior staff members, the growth being completely absorbed by the regional programs. The restricted funds available have not allowed for any real growth since 1980, in fact there

has been less money available than previously. In the CIMMYT Briefing Book prepared for this review there were 14 sub-programs or activities identified in the Wheat Program. Most of these were given priority ratings on a sub-program basis and certain elements were targeted for reduction or elimination if funds were not available. A brief summary is given here:

Sub-program or activity	Priority*		If serious reduced funding 1982-87
	1976-81	1982-87	
Bread wheat improvement	High	High	Eliminate
Durum wheat improvement	High	High	
Triticale improvement	High	High	
Barley improvement	(NA)	High	
Pathology research	High	High	
International testing	High	High	Seek spec. funds
Special germplasm develop.	(NA)	(NA)	
Wide crosses	Low until '80	High	
Germplasm bank	Low until '80	Intermed.	Reduce planned work
Industrial quality	High	High	
Agronomy research	(NA)	High	Reduce post doc & visit. scientist numbers
Training	High	High	
Regional	High	High	
Bilateral	(NA)	(NA)	Depends on opportunities for funds

\*NA = not available

What is CIMMYT considering in the future without such growth expectations? In what follows, some specific programmatic plans, given by CIMMYT, are outlined. These include only changes from the present programs.

### 7.1 Wide Crosses

C.90. Add more collaborative research to the present program. Examples are (1) through collaborative research with PBI, Cambridge, UK, a broader expertise in genetic manipulation is sought; and (2) through

collaborative research with Colorado State University, the exploitation of tissue culture techniques will be examined.

## 7.2 Germplasm Bank

C.91. Expand to the full scope, which has not yet been reached. This involves describing, sorting out, and computerizing the information for easy retrieval of all present entries and adding other entries which can be of use for CIMMYT's breeding program.

## 7.3 Germplasm Development

C.92. Develop, in cooperation with INIA scientists in northern Mexico, leaf-rust resistant multiline varieties based on several widely grown Mexican-CIMMYT varieties. Expand the program to improve spring rye for use in triticale breeding. Develop separate source populations (gene pools) in bread wheat, durum wheat and triticale for resistance to Helminthosporium sativum, H. tritici-repentis and Fusarium scab. Produce wheats with disease resistances, Al-tolerance, capacity for improved phosphorus extraction, etc. from rye through crosses with triticale. Substitute different cytoplasms from related wheat species into some triticale lines to see if this improves the triticales.

## 7.4 Breeding Programs

C.93. In general, the range of characteristics to select for will be further widened. Resistance to various diseases will be stressed even more than in the past. This, together with more attention to environmental stress factors, means that less effort can be given to improving yield potential unless the program is expanded. CIMMYT gives highest priority, however, to yield dependability.

### (i) Bread wheat

Work on wheats for subtropical areas will be strengthened through a special UNDP project grant. Special emphasis will be given to greater resistance to the barley yellow dwarf virus. Selection for higher biological yield while retaining the same harvest index and longer leaf area duration will be studied.



(ii) Durum wheat

More emphasis on drought tolerance, especially from spring x winter crosses, and resistance to stem rust.

(iii) Triticale

Selection for earlier types and resistance to preharvest sprouting will receive more emphasis. The genetic variation of triticale will be further broadened by producing new triticales and through introductions from other triticale programs. Through rye improvement, it is hoped to improve the triticales derived from them. From crosses between (introduced) winter and spring triticales, forage-type triticales will be selected. CIMMYT will assist National Programs in establishing triticale into widespread commercial production.

(iv) Barley

Improved disease resistance will be the major research thrust. Additional emphasis will be given to spring x winter crosses to develop late maturing, broadly adapted, high yielding varieties for long-season production areas, as well as increased efforts to get earlier maturing varieties for areas with a short season due to cold, drought or other reasons. Work on improving nutritional quality is diminished.

7.5 International Testing

C.94. The number of nurseries will tend to increase because of the broader scope of the breeding programs. Better use will be made of the data generated from all the international nurseries.

7.6 Regional Programs and Bilateral Programs

C.95. The regional programs form a relatively new addition and have not yet been fully established as planned. They have not reached the anticipated staffing and it is doubtful if that ever will happen. However, they will be strengthened as much as the budget will allow. With the present shortage of funds, more bilateral programs through extra core or special funding are sought. Projects in Turkey, Ethiopia, Peru and Brazil are under discussion.

## 7.7 Pathology

C.96. The range of pathogens studied and handled in the breeding program will widen. Population breeding (improving gene pools) will be explored as a means to develop suitable and durable resistance to Helminthosporium. Through special funding and collaborative research, work on Fusarium (scab), barley yellow dwarf virus, and Rhynchosporium (scald) will be expanded. The regional disease surveillance (trap) will be expanded to a global system.

## 7.8 Agronomy

C.97. In-service training will be increased through the headquarters, nationally-deputed, and regional staff. Increased collaboration with breeders is anticipated to develop criteria by which to screen germ-plasm for tolerance to environmental stress factors.

## 7.9 Training

C.98. More support will be given to in-service training programs within the regions and specific National Programs. More effort to develop more training-related materials for use in in-country training programs.

# 8. Assessment and Recommendations

## 8.1. Germplasm Bank

C.99. The Wheat Germplasm Bank, being a new unit, has not yet achieved its short-term goal of multiplying and documenting all of the seedstocks held since 1969. The first multiplication was done in the 1981-82 season at Cd. Obregon. The Panel found the Germplasm Bank to be an excellent facility, staffed by an experienced and enthusiastic curator. Many lines are being entered that originally came from CIMMYT, but were evaluated and selected in National Programs. In some, perhaps many, instances these lines would not be securely conserved in National Programs. The CIMMYT Wheat Germplasm Bank therefore serves an important worldwide

function for its cooperators as a working collection and has backup germplasm for use at any time. The Panel is pleased to offer its commendation and support to CIMMYT and the Japanese Government for their foresighted view on germplasm conservation. It is a treasury of valuable germplasm, vital in CIMMYT's future role in world food production, and we urge CIMMYT to expend all necessary efforts to complete the short-term goal of multiplication and documentation of the existing entries and to continue evaluation and entry of new accessions to the Bank.

## 8.2 Wide Crosses

C.100. The wide-cross program is a forward-looking program within the conventional wheat, barley, and triticales improvement programs. The methods used and the goals established for the program are well known and valid. Of greatest potential for transfer and integration into wheat chromosomes are genes for simply inherited traits such as disease resistance. The donor species for this work (Elymus giganteus and Agropyron distichum) are appropriate for investigation. They have not been exploited by others in the past and the early results presented to the Panel suggest that the program will accomplish its goals of developing chromosome addition and recombinant lines. The program presents a higher risk than the conventional breeding programs, and there is as yet no assurance that it will be successful as a source of genes for the germplasm development and breeding programs. The Panel is well-satisfied with the scientific content of the program and the capability of the investigator and endorses its continuation with critical annual reviews of progress. Since the goals include the transfer of complex traits such as drought and salinity resistance, the Panel strongly urges that CIMMYT by its own means develop and use accurate methods for evaluation of these traits.

## 8.3 Germplasm Development

C.101. The Panel was pleased to see the progress made in the GPD program and recognizes this activity to be of utmost importance for CIMMYT in the long range improvement of wheat, barley, and triticales. As currently structured, the GPD unit is both radical and conservative.

C.102. Its radical elements include redesigning the wheat plant in several important aspects. As the Panel had opportunity to observe, some of the goals of the program mentioned in section 3.3 above were practically met. The traits (branched spike, large seeds and others) may or may not be expressed in future wheat varieties, but even partial expression of some of these traits could lead to new heights in yield potential. It is the Panel's view that success is not assured with this approach, but agrees that bold approaches in germplasm development are needed and appropriate for an international center and suggests continuation and expansion of this work.

C.103. On the conservative side of this program is the methodical transfer by backcrossing of genes to well-known cultivars. This is a routine and usual procedure for breeding programs and could be combined as part of the breeding program rather than as germplasm development. This includes genes for rust resistance, solid stems, and plant height. The outcome of this program is a group of lines (called isolines) that are indistinguishable from a prototype variety (such as INIA 66, an old but widely adapted variety) except for some specific trait such as disease resistance. These lines are then used in the plant breeding program to create new combinations of resistance genes (called pyramiding) in efforts to develop longer-lasting resistance. This effort provides valuable germplasm for use by breeders in National Programs. In some instances this procedure can provide ready-made varieties in the Germplasm Bank to provide an "insurance policy" against the time when existing varieties may be rendered ineffective because of certain diseases. The Panel notes that one scientist is assigned to GPD and recommends, because of its importance for longrange improvements, an expansion of effort, if necessary by contributions of effort from breeders of the bread wheat, durum wheat and barley breeding programs.

#### 8.4 Breeding Programs

C.104. The breeding programs in the four crops are set up along the same pattern, a pattern that is accepted by the Panel as adequate for these crops. This includes testing and selection of the parents, crossing these

parents and selecting through the segregating generations the best genotypes (advanced lines). The feature that CIMMYT has successfully promoted is a strong emphasis on broad adaptation through the alternate testing in winter at Obregon and in summer at Toluca and El Batan, and through the international nursery testing. This has been criticized in some scientific circles based on the idea that such broadly adapted varieties could not reach the level of the best locally adapted varieties. At the same time, it was suggested that the CIMMYT varieties would predominantly be suited only for high yielding environments. Through recent collaborative research with German scientists, using the yield data of the International Spring Wheat Yield Nurseries over the last 15 years, it was shown that there was no indication that the high yielding CIMMYT varieties were typically responsive to high yielding environments only. Also, it was shown that nearly everywhere the best CIMMYT varieties were broadly adapted and outyielded the local varieties. Conclusions from the latter observations should be drawn cautiously, however. In many cases, the local check varieties came from National Programs of a much smaller and less aggressive type than CIMMYT represents. One program based on broadly adapted varieties is, of course, considerably more cost-effective than many regional breeding programs. The Panel strongly encourages the continued pursuance of broadly adapted, yield dependable varieties.

C.105. The increased emphasis of the Wheat Program on improving yield stability, through selection for resistance to diseases, pests and environmental stresses, is desirable since relatively high yield potentials has been achieved in many materials. However, if the staffing and resources of the program are not expanded at headquarters, emphasis on selection for resistance to biological and environmental stresses may result in slower gains in yield potential in the future. At this time, the breeding program is making progress in both increasing resistance to diseases and in increasing yield potential. However, drought, salinity, and temperature extremes are major problems confronting wheat production. The Panel recommends that the Wheat Program give more emphasis to the development and use of methods for screening for resistance to drought, salinity, and temperature extremes. This will require addi-

tional strength at headquarters with specialization on whole-plant responses to environment with emphasis on drought. In the event that funds and positions are limited, it is recommended that a senior agronomist/crop physiologist be hired to provide essential support to plant breeders in both the Wheat and Maize Programs, since the maize program is also placing emphasis on improving resistance to drought.

C.106. Within this pattern of seeking higher yield dependability, selection for durable types of resistance to rapidly adapting pathogens such as the cereal rusts is of great importance. The present procedures of selection for disease resistance do especially favor the major-gene resistances and these are the ones that are so easily overcome by the adaptable pathogens. Selection of lines and varieties that are "slow rusting" and/or have across locations a uniform low coefficient of disease is probably not sufficient to counteract the strong selection pressure for major gene resistances present in the programs. The Panel therefore recommends that more emphasis be given to selection for and to research on durable resistance.

C.107. Most of the yield increases in wheat and barley were obtained by increasing the amount of grain produced as a proportion of the above-ground biomass (called harvest index, HI). Total biomass production has virtually remained unchanged throughout the course of CIMMYT's variety improvement programs. There is, however, a limit to the HI and this may be already achieved in wheat. Further yield increases must therefore come from increases in biomass while maintaining a high HI. Future breeding will place more emphasis on the development and use of selection methods that allow for selection for higher biomass and longer leaf area duration. The Panel agrees with that approach and recommends systematic study of selection responses using those criteria.

C.108. In the case of triticale, a special situation exists. It is a new, manmade crop with a long history of rather unsuccessful probing, but with a great response in the last 15 years. However, the genetic variation within triticale is still small compared to that within the other crops. All well-directed efforts to broaden this germplasm basis

are therefore of great importance. CIMMYT proposes more wheat x rye crosses, introductions of triticales from other programs, and improvement of rye before crossing with wheat. These are indeed good approaches. The importance of the improved triticale is that its quality for industrial purposes is slightly lower than that of wheat, while its performance as a feed is equal to that of wheat and other grains. Its biomass is often higher than that of wheat, while its HI is generally lower, leaving considerable room for yield improvement. The Panel recommends that the broadening of the germplasm base as well as the selection for high yielding earlier-maturing triticales should have a high priority.

C.109. The Wheat Program presently gives virtually no direct attention to development of winterhardy germplasm of barley and bread and durum wheats and the Panel recommends greater allocation of resources to this need.

C.110. The Panel notes that high-protein, high-lysine barleys with well-formed grains have been developed. This is an important achievement and, while we agree with the Program decision to decrease emphasis on developing barleys with improved nutritional quality, the Center should guard against the loss of the high-lysine characteristics in its breeding program.

#### 8.5 International Testing

C.111. The number and size of international nurseries has expanded in recent years, both from headquarters and from regional programs. The Panel suggests that CIMMYT become more selective in the composition and distribution of international nurseries and recommends that increased attention be given at headquarters to the analysis and interpretation of the data received.

#### 8.6 Regional Programs and Bilateral Programs

C.112. Regional programs are an effective means by which CIMMYT can realize its objectives of spreading germplasm and knowledge to

National Programs. Unfortunately, due to CIMMYT's curbed budget, the anticipated manpower in the regions has not been fully realized. The Panel notes that active breeding participation by CIMMYT staff exists in Kenya, Portugal, Syria, Ecuador and Chile. The Panel recognizes the importance of the regional programs and urges that these should be manned as well as possible, however, without affecting the quality of the headquarters program. This means also a close cooperation with ICARDA. Bilateral programs, through special funding, may fill the gaps in the regional programs to a certain extent and should for this reason be encouraged.

#### 8.7 Maintenance of Recommended Varieties and Seed Production

C.113. Seed multiplication and distribution is the responsibility of the countries that release varieties. The maintenance, multiplication and distribution of these varieties is insufficient in most developing countries. The Wheat Program has not given concentrated effort to seed production. The Panel recommends that CIMMYT consider seriously increasing its role in promoting seed production systems in developing countries.

#### 8.8 Pathology

C.114. The Wheat Program's pathologists have a wide range of activities that are well-integrated with the breeding program to support the selection of resistant varieties. These activities are viewed principally as support services within the Wheat Program. The Panel recommends that disciplinary research in plant diseases and pest management receive more attention, as for instance in the production of parental lines with durable resistance to pathogens, in the study of the genetics of resistance to major diseases, and by in-depth analysis of disease surveillance data.

#### 8.9 Milling and Baking Quality

C.115. This appears to be a well-organized support service which gives highly useful information about wheat and triticale quality for



a wide range of industrial uses. The Panel encourages CIMMYT to maintain this flow of information.

#### 8.10 Agronomy

C.116. The Wheat Program agronomy activity at headquarters is viewed as a support service to the breeding programs of CIMMYT. As such it is meant to contribute to the effectiveness of the breeding program through cultural practices that will result in greater efficiency in handling breeding materials, as by efficient weed control methods, or by direct evaluation of variety responses to crop management, such as fertilizer x variety interactions on CIMMYT experiment stations.

C.117. The results of numerous weed control experiments as reported in the "CIMMYT Annual Report on Wheat Improvement" indicate that a careful assessment of new chemicals has been done. Recent results showing the value of specific management practices and crop rotations provide an excellent framework for similar studies in developing countries where herbicide applications might not be feasible. The Panel believes that much of this work, while not site-specific, should be done within targeted countries and therefore recommends that agronomic studies at headquarters be minimized and carried out only to the extent necessary to solve local weed control problems or to serve as a training function.

C.118. As CIMMYT increases its commitment to germplasm development for semiarid environments, it will be essential that better understanding be obtained of responses of wheat, triticale and barley to stress conditions. The Panel, therefore, notes that increased attention must be given to developing screening methods for adaptation to water-limited environments.

C.119. Further, the Panel was pleased to learn of the progress made in selecting for resistance of wheats to low soil pH and high soil aluminum content. It appears that future improvement of small grains will be enhanced by more careful attention to problem soils having other mineral element toxicities, especially salinity effects. The Panel believes this

opportunity to be of sufficient importance to recommend that a substantial research effort be addressed to plant, soil and water relationships, and that an agronomist/crop physiologist be appointed. (This staff appointment is intended to be the same one as recommended in section 8.4 above.)

C.120. Previous agronomic research conducted under a crop physiology program, discontinued in 1975, was very successful in developing information about growth and development of the cereal plant in near-optimum and suboptimum conditions. A renewed commitment by CIMMYT to the integration of agronomic performance characteristics with breeding goals is suggested by the Panel. The Panel believes this to be an appropriate thrust for a Center with interest in crop improvement on a global basis. This could be accomplished with the staff scientist position recommended above.

C.121. The Panel was informed that the agronomists view service at CIMMYT headquarters as a training ground and even a stepping stone to a regional assignment. This experience is valuable, and perhaps necessary, for effective extension of CIMMYT's materials and methods to developing countries, but the Panel notes that this can result in a lack of depth and experience in the senior staff at headquarters. Appointment of the senior staff member recommended in section 8.4 above would provide continuity in research and training.

#### 8.11 Training

C.122. This activity is regarded with high priority within the Wheat Program. The Panel members found high regard for the various training programs among graduates that they interviewed in various countries. It was acknowledged by some former trainees that similar training could be organized in their home country, but they felt strongly that the enthusiasm seen in the programs in Mexico had a positive effect on their attitudes toward research. A second positive but intangible factor cited by former trainees was the confidence gained in acquiring first-hand experience in doing all of the operations of a breeding or research program. The Panel believes that the in-service training courses should be continued.

C.123. The Panel noted that a substantial number of trainees completed courses each year. It appeared to be about the maximum number of trainees that could be accommodated given the amount of resources allocated to this activity. The Panel was also informed that the production agronomy courses had been reduced from two per year to one, with the irrigated agronomy aspects to be included as an additional three weeks to the rainfed agronomy course. Several reasons were cited for this curtailment of program, but it appeared to the Panel that insufficient resources were being supplied to the Training Staff and insufficient materials to support this activity to the level expected of CIMMYT. Production agronomy was repeatedly mentioned by staff as being the major limitation to increasing production in developing countries. The Panel recognizes the agronomy training courses as being vital to National Program development and therefore recommends a review of the staffing policy, program goals, course content, and training materials.

C.124. The breeding and pathology and cereal technology courses give greatest attention to field or laboratory experience in the on-going programs. Apparently little special effort is given to preparing special projects or demonstrations for the trainees. Because a wide variety of situations appear in each cycle, this is not viewed as a severe detractor to the program. The experiment station management course appeared to be extremely valuable and one of the very few such courses in the world. The number of students that could be admitted to that program appeared to the Panel to be its only limitation.

C.125. In the training courses the Panel noted that training manuals and instructional aids, such as multi-language audio-tutorial materials, were inadequate or absent and urges that they be updated or developed.

C.126. The Panel recommends that strong efforts be made to coordinate and improve the training programs in wheat, maize and economics as described in Chapter I.

C.127. The postdoctoral fellowship program is used as a training ground for new graduates who would like to establish careers in international

agricultural research and development. A rather high percentage of CIMMYT postdoctorals have advanced to staff positions in CIMMYT or other IARCs. In that sense, the Panel judges the postdoctoral program to be successful. However, the Panel notes that the postdoctoral fellows, while experiencing all phases of the research or breeding programs, do not have special research topic responsibilities and therefore made minimal contributions to new knowledge in their respective fields. The Panel recommends that postdoctoral assignments provide more opportunity for specific research within the programs to which they are assigned.

C.128. The visiting scientist program and predoctoral training activities appear to be extremely valuable. The Panel encourages that these activities be continued to the fullest extent possible.

#### 8.12 Communications

C.129. Cooperators find the International Nursery Reports to be extremely useful for information on performance and disease reaction of germplasm. These are prepared and distributed in reasonably good time. The Annual Reports give more detailed research results and are likewise widely used by wheat, barley, and triticale scientists. However, these reports appear two to three years after the work has been completed. Regional workshops have been organized by CIMMYT and the proceedings are published, but, like the Annual Reports, these often appear several years after the conference. These have limited distribution in the scientific community and the Panel suggests that the value of such publications be reconsidered.

C.130. The Panel found that the Wheat Program staff had completed research projects, but had made few contributions to scientific journals in the past five years. It may be true that the major findings were made available to those directly interested through other means, but the Panel considers that CIMMYT's research should be reviewed and published in journals having wide distribution in the scientific community, and therefore recommends that the scientific staff present their findings to such journals.

C.131. Detailed reports, too extensive or specific for publication in journals, should also be published and we suggest that the CIMMYT research bulletin series be reinstated.

C.132. In spite of rapid delivery of nursery reports, there is a time lag in communicating interesting new findings to the international network of cooperators which CIMMYT serves. Such information, including personal items, could be communicated regularly in a newsletter. Regional staff and cooperators could also be encouraged to contribute newsworthy items. The International Rice Research Newsletter and the IRRI Reporter could serve as models. The Panel hopes that consideration will be given to this form of communication.

CHAPTER D  
MAIZE PROGRAM

1. History and Background

D.1. The Maize Program emphasizes the development of improved maize genotypes for grain production in developing countries. It includes mechanisms for integrating breeding activities with delivery systems, and assists National Programs in many aspects of maize production and training.

D.2. The Program is a direct outgrowth of a cooperative project between the Government of Mexico and the Rockefeller Foundation which began in 1943. From its initiation in 1966, CIMMYT gave emphasis to the improvement of maize populations and refinement of methodologies for population improvement on an international scale. By the early 1970s some improved maize populations had been developed, and it was assumed that they would be useful to National Programs, but the populations were only used by a few strong National Programs. In 1973 the breeding and training components were reorganized. More emphasis was given to assisting National Programs to develop useful open-pollinated varieties from the materials provided by the Maize Program. In the late 1970s, several National Programs began to release improved open-pollinated varieties as a direct result of the germplasm, breeding methodologies and assistance in training provided by the Maize Program.

D.3. In the last few years some assistance has been provided, on an ad hoc basis, to National Programs which want to develop maize hybrids. However, major emphasis continues to be given to the development of open-pollinated varieties by the cooperative efforts of plant breeders in the Maize Program and National Programs throughout the world.

D.4. Regional activities of the Maize Program have expanded during the last five years. The first regional program, which was an outgrowth of a Rockefeller Foundation program initiated in 1954, was established in 1974 for the Central American and Caribbean Region. Between 1976 and

1981, four additional regional programs were initiated. They provide important contributions to the overall system for improving maize germplasm, they assist National Programs to develop research programs in production agronomy and they coordinate training activities within the region.

D.5. Bilateral National Maize Programs of CIMMYT have been reduced during the last five years. In 1976, CIMMYT had 11 maize staff members assigned to six National Programs. By 1981, CIMMYT had only three maize staff members assigned to three National Programs.

## 2. General Objectives

D.6. The overall objective of the Maize Program is to provide National Programs with the "intermediate" goods and services that are essential for the improvement of maize productivity, production and utilization in developing countries throughout the world.

D.7. The Maize Program considers, however, that it will be partially judged by the improvements in maize production that are achieved by developing countries. Consequently, it gives considerable emphasis to assisting National Programs to make effective use of the germplasm and services that it provides.

D.8. The general objectives of the Maize Program are pursued by plant breeding, agronomy, economics, training, and communications.

- a) Through plant breeding: develop germplasm and breeding methods which will enable National Programs to develop maize cultivars for different production environments, which have higher yield potential, improved stability (through broad adaptation and increased resistance to pests, diseases, and environmental stresses), and improved nutritional characteristics.
- b) Through agronomy and economics: assist National Programs to develop improved maize production technologies for the different production environments of developing countries and improved systems for producing seed, and provide feedback advice to the plant breeders of CIMMYT concerning the germplasm that is needed.

- c) Through training: assist National Programs to develop the teams of trained staff needed for improving maize production, improve the awareness of national scientists concerning the germplasm and methods developed by the Maize Program, and enhance cooperation among staff of National Programs and the Maize Program.
- d) Through communication: assist the various sections of the Maize Program to achieve their objectives, and provide a clear description of the activities, goals and accomplishments of the Maize Program to those people in the outside world who influence or who are influenced by the activities of the Maize Program.

### 3. Program Structure and Procedures

#### 3.1 Germplasm Development and Population Improvement

D.9. The present maize breeding program was established in 1973. The basic structure of the program has not changed since that time but some important components have been added to it. There are four main stages in the breeding program: (1) the creation, evaluation and storage of new germplasm; (2) the development and improvement of broad-based gene pools for different, specific areas of the world; (3) the continuous improvement of populations, based upon these gene pools, and (4) the development of superior experimental varieties from the populations.

##### 3.1.1 Germplasm Bank and Wide-Cross Unit

D.10. The maize Germplasm Bank presently contains 14,000 accessions most of which were collected in countries in Central and South America, and the Caribbean. A few accessions were obtained from the Middle East, South and South-East Asia, China and Africa. The Maize Germplasm Committee of IBPGR considers that collection of maize germplasm has been substantial and that further collection is only needed in the north eastern Himalayan region and a few other small areas. IBPGR has agreed to give attention to collection of maize germplasm in these areas. The CIMMYT maize germplasm bank also contains a few accessions of wild relatives of maize (e.g., Teosinte and Tripsacum spp.).



D.11. Duplicate samples of accessions are sent to the National Seed Storage Laboratory (NSSL) in Fort Collins, USA for secure, long-term storage. At this time 3,854 samples have been sent to NSSL.

D.12. Some of the accessions and new introductions are evaluated each year at different sites in Mexico. Accessions with desirable characteristics that suit a particular gene pool are incorporated into it.

D.13. Certain problems jeopardize the future of the Germplasm Bank. The present facilities can only store up to 15,000 accessions. Regeneration is limited by the availability of funds (extensive hand-crossing is needed), and lack of facilities in the ecological zones needed for regenerating some of the accessions. In addition, the Maize Germplasm Committee of IBPGR considers that more effort should be devoted to evaluating accessions. However, the Maize Program of CIMMYT places a relatively low priority on the evaluation and regeneration of material in the germplasm bank, as they believe that they already have adequate genetic variability in their gene pools.

D.14. A major objective of the Wide-Cross Unit is to transfer desirable traits to maize which are only found in other genera. CIMMYT initiated this work in 1974 with first priority on crossing maize and sorghum in an attempt to transfer the ability of sorghum roots to withstand waterlogging and drought into maize. Second priority was placed on crossing maize and Tripsacum to incorporate resistance to certain diseases and insects into maize.

D.15. Thousands of sexual crosses have been made with maize x sorghum, yet no cytologically confirmed hybrids have been produced. A collaborative research project with PBI, Cambridge, UK has been initiated to gain a better understanding of the genetic mechanisms involved in this cross in the hope that this will make it possible to obtain hybrids.

D.16. With the maize x Tripsacum cross a significant number of hybrids have been produced. Unfortunately, Tripsacum has a gametophytic factor which causes a sterility barrier to self or cross pollination. Use of

maize genotypes containing a gametophytic factor and proposed collaborative research with the University of Illinois may solve the sterility problem. The Maize Program estimates that the Tripsacum project could produce material for field testing within 1½ years.

### 3.1.2 Gene Pool Improvement and Characterization

D.17. The Back-Up Unit of the Maize Program is responsible for gene pool improvement, and for the germplasm bank and new introductions. Most of the pools are managed in Experiment Stations in Mexico. Each pool is normally grown at two to three locations and maintained at approximately 500 families. For recombination and improvement of the pools, a half-sib mating system and selection between half-sib families are used. New introductions are tested as females in comparison with the material presently in the pool. In this way new introductions are evaluated for their suitability to enrich the pool over two seasons before they are put into the pool. A low level of selection pressure is applied to maintain a broad genetic base.

D.18. The Maize Program has assembled 33 gene pools to serve different maize-growing regions around the world--an increase of 13 new pools since 1976. Each of these pools originated from genetically diverse maize populations from many countries but with specific climatic adaptation (tropical lowlands, tropical highlands, subtropical or temperate), maturity characteristics (early, intermediate or late), grain type (flint, dent, floury or Morocho), and grain color (yellow or white). At present, there are 12 pools for the tropical lowlands, 8 for the tropical highlands of the Andean region, 1 for the African highlands, 8 for the subtropics and 4 for temperate zones.

D.19. Some of these pools are being shared with National Programs where they are used for developing open-pollinated varieties and hybrids (e.g. pools 19 and 20 in Mexico, 16 in West Africa, and 17 in India).

D.20. In 1978, CIMMYT's program for the Andean highlands was reorganized. A shuttle breeding system was instituted whereby pools which are to be

used in the highlands are improved for agronomic characters in Ecuador, and for resistance to ear rots and ear worm in Mexico.

D.21. A cooperative project for developing a temperate-tropical maize gene pool was established with scientists at Hohenheim University, West Germany in 1976. The objective of this project is to create a genetic bridging mechanism, and introduce tropical germplasm into temperate materials, and temperate genetic resources into tropical germplasm.

### 3.1.3 Population Improvement and International Trials

D.22. The Advanced Unit and outposted staff of the Maize Program are developing a range of advanced materials (populations and experimental varieties) that are suitably refined in yield potential, agronomic characters, and stability to serve the germplasm requirements of National Programs.

D.23.. Populations have been derived from the gene pools (normally one per pool) and are improved using a full-sib breeding and selection system. Selection is based upon field testing in Mexico and feedback from the National Programs participating in the International Progeny Testing Trials (IPTTs).

D.24. The IPTTs have two objectives: improving the populations, and delivering germplasm to National Programs. Once every two years, 250 families from each population are evaluated at six locations. The populations are improved by selecting 30 to 40% of the superior full-sib families from each population. Also, the ten best families are selected at each site by National Program staff, and they are recombined by CIMMYT using diallel mating to produce an experimental variety for that site. In addition, the ten best families across all sites are used to form a broadly adapted experimental variety. At present, 27 populations are included in the IPTTs (24 normal and 3 quality protein maize populations).

D.25. The experimental varieties produced using the selections from the IPTTs are distributed to National Programs for testing in Experimental

Variety Trials (EVTs). The entries in the EVT's with the best performances are chosen for the Elite Experimental Variety Trials (ELVTs).

D.26. Populations (and experimental varieties ) destined for environments with climates or diseases not found in Mexico are improved by out-posted CIMMYT staff.

D.27. The number of countries participating in the international trials has increased from 49 in 1976 to 84 in 1981. Virtually every maize-producing country in the developing world is included in the international maize testing network. During the period from 1975 to 1981, 650 experimental varieties have been developed using the results of the IPTTs.

### 3.2 Selection Criteria and Procedures

D.28. In addition to the more conventional selection criteria used in many breeding programs, the Maize Program puts considerable emphasis on nutritional quality, resistance to diseases and pests, and physiological criteria that are relevant to yield potential and resistance to drought.

#### 3.2.1 Nutritional Quality Improvement

D.29. The major objective of this sub-program is to improve the nutritional quality of maize without sacrificing yield using the opaque-2 gene in combination with other genetic modifiers. Hard endosperm, quality protein maize (QPM) versions of CIMMYT's normal gene pools and populations are being developed with improved yield and resistance to insects and disease.

D.30. Modified recurrent selection/back-cross breeding has been used since 1974 to accumulate genetic modifiers in the opaque-2 background to improve endosperm hardness and agronomic performance. Four tropical and three subtropical QPM gene pools have been maintained and continuously improved by half-sib breeding. Since 1978, three QPM populations have been included in the IPTTs.

D.31. The Maize Program has reported that the problems originally associated with opaque-2 maize, such as reduced yield, vulnerability to ear rot and stored-grain pests, and the chalky appearance of the grain have been largely overcome. Various normal-looking white and yellow grain QPM materials have been developed which have produced yields equal or superior to normal check varieties presently cultivated in Latin America, Africa and Asia.

D.32. Many National Programs have now tested QPM materials in breeding nurseries and farmers fields. Apparently some of the enthusiasm of the early 1970s for high lysine maize may be returning. Some of this interest in QPM is for commercial production in developing countries to supply feed for pigs and poultry because it has substantial advantages over normal maize as a feed. In addition, there is interest in some countries (e.g. Guatemala) in using QPM as a direct source of human food for subsistence farmers and their families to improve human nutrition.

D.33. Wide spread adoption would require that QPM materials be easy to manipulate by breeders in National Programs. CIMMYT scientists are developing methods to assist breeding with QPM materials to include more effective modifier genes, and genetic methods to prevent contamination of QPM populations.

D.34. Maize Program scientists were encouraged by an earlier external review panel to conduct a modest amount of exploratory research to improve other nutritional quality aspects of maize, such as increasing oil content. It had been argued that it might be useful to increase the number of calories in maize kernels. Many questions can be raised concerning this project. For example, would increases in oil content increase or decrease the number of digestible calories produced per hectare? Would increases in oil content increase consumer acceptance of maize products or decrease acceptance through enhanced rancidity in storage? At present, this work is limited to only one tropical and one subtropical QPM population.

### 3.2.2 Resistance to Diseases

D.35. A major objective of selection at CIMMYT's experiment stations in Mexico is to develop stable resistance in CIMMYT pools and populations to ear and stalk rots, and certain foliar diseases that are present in Mexico. Selection for resistance to diseases is integrated into the main breeding program. Artificial inoculum is used to apply selection pressure for resistance to ear and stalk rots, and leaf blights and rusts.

D.36. It was reported that over the last five years CIMMYT maize pools and populations have shown increased resistance to ear and stalk rots, and to the rusts and leaf blights which can be effectively handled in Mexico.

D.37. In 1974, three collaborative breeding projects were organized between CIMMYT and six National Programs to develop germplasm resistant to three major diseases of maize in tropical areas. One project focuses on downy mildew which mainly occurs in Southeast Asia but has now become an important disease in parts of Africa and Latin America. Another project deals with maize streak virus which is transmitted by a leafhopper and is present throughout tropical Africa. The third project focuses on corn stunt which is also transmitted by a leafhopper but mainly occurs in tropical Latin America and southern USA. A shuttle-breeding strategy is being used by these projects to improve broadly-based populations by alternating cycles of selection for resistance to the diseases in the collaborating countries and selection for improved agronomic characters in Mexico.

D.38. By 1980, four cycles of selection had been completed for resistance to downy mildew in Thailand and for corn stunt in Central America. At this time, three advanced populations for tropical lowlands (Nos. 22, 28 and 31) are being improved by increasing their resistance to downy mildew in the cooperative program with Thailand. Progress has been made in developing populations and high-yielding varieties with field resistance to downy mildew and corn stunt.

D.39. The work on streak virus is less advanced due in part to ineffective cooperation between IITA and CIMMYT in earlier years. This activity was reorganized in 1980 as part of the CIMMYT-IITA West African Regional Program which involved placing two staff members of the CIMMYT Maize Program at IITA. Suitable insect-rearing facilities for the leafhopper vector and good sources of resistance to streak virus were developed by IITA and are now available for this collaborative project in Africa. Population 43 and eight experimental varieties are being improved by increasing their resistance to streak virus.

### 3.2.3 Resistance to Insects

D.40. A major objective of selection at CIMMYT's experiment stations in Mexico is to develop resistance to fall armyworm, ear worm, sugarcane borer, and Southwestern corn borer. These insects are important pests in Latin America, the Caribbean, and southern USA.

D.41. During the last five years, insect-rearing facilities have been developed for all of these insects. In addition, an inexpensive technique has been developed for infesting maize plants with a specified number of larvae. This simple technique has been adopted by maize scientists all over the world who are breeding for resistance to insects.

D.42. Selection for resistance to insects is integrated into the main breeding program. Considerable progress has been made in improving resistance to fall armyworm in two pools and two advanced populations. Less progress has been made with developing resistance to earworm, sugarcane borer, and Southwestern corn borer.

### 3.2.4 Crop Physiology

D.43. The major objective of the crop physiology sub-program during 1976 to 1981 was to evaluate selection techniques for improving yield efficiency, drought resistance, early maturity and wide adaptation in tropical maize.

D.44. Most of these projects were evaluated in 1980 to determine their progress and whether they should be continued. This led to a decision that the concepts developed in the work on yield efficiency and wide adaptation would be integrated into the main breeding program.

D.45. The major conclusions of the studies on yield efficiency were that selection for shorter plants resulted in increases in grain yield/ha, provided higher planting densities were used. The increases in grain yield were associated with increases in harvest index. Some gains in yield efficiency were also made by selecting for smaller tassels and reduced leaf area. Greater emphasis is now placed on all of these traits in the pool and population improvement programs.

D.46. The work on wide adaptation began with the assembly of a population using germplasm from many temperate and tropical environments. Initially, certain materials would not set seed in certain environments because of differences in sensitivity to day length and temperature extremes. After 13 cycles of recombination and selection, a population has been developed which sets seed in a range of maize-growing environments. CIMMYT's interest in crossing temperate and tropical germplasm has now expanded and this work has been assigned to the Maize Program's Back-Up Unit.

D.47. Work initiated in 1976 to test and develop screening techniques for drought resistance is continuing at this time. This work demonstrated that genetic variation for drought resistance was present in families from a Tuxpeño population. It was also demonstrated that a special multiple selection index could be used to identify families and develop varieties that give better than average yields when subjected to drought, and still have high yields under more favorable environmental conditions. It is not known at this time whether the special multiple selection index is significantly more efficient in improving drought resistance than the multiple-trait selection index currently employed in the Advanced Unit-international testing program.



D.48. The work on early maturity resulted in the development of some early-maturing families which have been used to form two new Advanced Unit populations (nos. 30 and 31). These populations are now included in the international testing program, and early-maturing experimental varieties are flowing to National Programs. A conclusion from this work is that as one selects for earliness there is a tendency for selection towards shorter and more efficient plants, and that yield is not adversely affected providing planting density is increased.

### 3.3 Associated National Program Activities

D.49. Some of the activities of National Program staff are described which are essential to the achievement of general objectives, and which illustrate important interactions between staff of the Maize Program and National Programs.

#### 3.3.1 Contribution to Population Improvement by National Programs

D.50. An important feature of the Maize Program is that National Program staff contribute to the improvement of populations by selecting families in the International Progeny Testing Trials. These families are then used in the recurrent selection procedures of CIMMYT to develop improved populations. This direct involvement of National Programs in CIMMYT's maize breeding contributes, not only to its functional efficiency, but also to the development of mutual cooperation and partnership.

#### 3.3.2 Development and Release of Varieties and Hybrids

D.51. National Program staff are also directly involved in selecting the families (through progeny trials on their experiment stations) that are then used by CIMMYT to develop experimental varieties for them and for other National Programs. The release and naming of varieties is determined by National Programs.

D.52. CIMMYT Maize Program was designed to help National Programs to produce open-pollinated varieties either by direct use of experimental

varieties or by further breeding and refinement of CIMMYT materials by National Programs.

D.53. Arguments are presented which support this strong emphasis on open-pollinated varieties by the Maize Program because it has been a controversial point for many years.

1. Development of open-pollinated varieties requires less skill and technology, and is more likely to be conducted effectively by National Programs which have limited resources, than the development of hybrids.
2. Hybrids require more sophisticated systems of seed production and distribution which are generally not present in developing countries.
3. Hybrids are more uniform than open-pollinated varieties and may have less yield stability due to less genetic buffering.
4. An international program which is developing inbreds to support hybrid breeding by National Programs could lead to a narrow genetic base for the maize grown over a large region (National Programs would likely focus on only the best inbred combinations). Uniform materials with a narrow genetic base would be uniformly vulnerable to new virulent races of pathogens.
5. The present Maize Program of CIMMYT has materials and methods which are being supplied to those National Programs wishing to pursue the development of hybrids. CIMMYT has detected materials among the various populations which produce lines with good combining ability and suitability for different maize production areas.

D.54. The major arguments in favor of hybrids based on inbred lines are that they can be extremely uniform, which is important with mechanical harvesting but frequently a disadvantage for subsistence farming, and that they have higher yield potential. It may be anticipated that the best hybrids produced using two populations will outyield the best open-pollinated varieties developed from the same populations. However, one must also take into consideration the time required to develop the hybrid, because 8 to 9 generations are needed. During this time, the population will have been advanced 2 to 3 cycles. Open-pollinated

varieties developed from the last cycle may perform nearly as well as hybrids developed from earlier populations.

D.55. In comparing open-pollinated varieties and hybrids, it is necessary to consider the "hybrids" that may be produced by crossing CIMMYT's advanced populations, experimental varieties or full-sib families from different advanced populations. Those procedures are less complicated and take fewer generations than the production of hybrids from inbred lines, and the "hybrid" that is produced has slightly more genetic buffering than hybrids from inbred lines. CIMMYT has assisted National Programs in Ecuador and Guatemala to produce successful "hybrids" by crossing full-sib families from different advanced populations.

### 3.3.3 Seed Production

D.56. Seed production is the responsibility of National Programs but it is regarded as a major bottleneck to the improvement of maize production in many developing countries. Consequently, CIMMYT staff have been providing assistance to National Programs concerning seed production. This assistance has consisted of developing methods for varietal maintenance and seed production with open-pollinated varieties, and providing informal advice to National Programs.

## 3.4 Regional, Bilateral and Collaborative Projects

### 3.4.1 Breeding

D.57. Regional Maize Programs of CIMMYT have expanded during the last five years by the addition of four programs: (1) the Asian Regional Program which makes an essential contribution to the development of populations with improved resistance to downy mildew; (2) the Andean Regional Program which makes an essential contribution to the development of pools and populations for the highland tropics which have the special grain types (floury and a special flint type called Morocho) needed in the Andean Region; (3) the Middle East Regional Program which

is improving resistance to stalk rot in a subtropical population for this region; and (4) the West African Regional Program, which in collaboration with IITA, is developing materials with improved resistance to streak virus. The existing Regional Program in Central America and the Caribbean contributes to the development of improved resistance to corn stunt disease.

D.58. Collaborative research activities include assistance by Pioneer Hi-bred Co. in the regeneration and evaluation of lowland accessions in the CIMMYT maize germplasm bank. Collaboration on wide crosses includes studies on barriers to maize/sorghum crosses by PBI, Cambridge, UK; improvement of tissue culture techniques by Pfizer Genetics, Connecticut, USA; and improvement of alien pollen growth by USDA, Athens, USA. Pfizer Genetics is also screening CIMMYT's maize pools and populations for combining ability with superior US inbred materials. The development of broad-based germplasm for temperate areas is being pursued by collaborative research with the University of Hohenheim, West Germany, and Cornell, Iowa State and Kansas State Universities in the USA. North Carolina State University is screening CIMMYT's maize germplasm for reaction to root-knot nematode. Lastly, there has been a collaborative project at the University of Missouri (USDA), USA which focuses on grain quality. In this project the development of aflatoxins is being studied.

#### 3.4.2 Agronomy, On-Farm Research and Training

D.59. In the past, bilateral National Maize Programs of CIMMYT involved 11 maize staff assigned to six National Programs in Guatemala, Egypt, Nepal, Pakistan, Tanzania and Zaire. These programs focused on agronomy, on-farm research and training. During the last five years these programs have been reduced. At present, CIMMYT has only three maize staff members assigned to National Programs in Ghana, Pakistan and Tanzania, and it is anticipated that the special project in Tanzania will end in the near future.

D.60. The expansion of the Regional Maize Programs has concentrated on agronomy, on-farm research and training in developing countries. Formal in-country training mainly consists of training in procedures of on-farm research in cooperation with the Economics Program of CIMMYT. In addition, workshops and field tours have been organized for regional scientists. Contributions to agronomy consist of encouraging and assisting National Programs to develop production agronomy research programs, with emphasis on on-farm research to develop appropriate production technology.

D.61. The major maize production areas of the world are covered by the five regional programs which include 51 countries, and there are only 11 regional staff members who individually have many different responsibilities. The extent to which the contributions of the regional staff are focused, rather than comprehensive, varies.

D.62. In the past, some of the focused outreach efforts have made possible considerable progress. A synopsis is presented of a project in Guatemala which was conducted as a bilateral project from 1976 to 1980, and which is now part of the Central American Regional Program.

D.63. In this project the CIMMYT Maize Program assisted the National Program of Guatemala (ICTA) to develop superior maize varieties and "hybrids" and cultural practices adapted to the circumstances of Guatemalan farmers. In 1976, Guatemala imported most of its maize seed, whereas in 1981, most of the maize seed was produced by Guatemalan farmers and processed by ICTA. From 1976 to 1980, ICTA conducted 2,696 different maize trials, of which 2,100 were conducted on farmers' fields. Several superior open-pollinated varieties and "hybrids" have been adopted by a high proportion of Guatemalan farmers (70% of the maize area in the lowlands and 40% in the highlands). In addition, trials have been conducted with Quality Protein Maize varieties. Over the four years of the project, twelve in-country training courses were offered to ICTA technical personnel, and ten conferences on maize production were conducted with Guatemalan extension personnel. CIMMYT staff members directed the thesis research of 15 students who obtained B.S. degrees, and four M.S. students.

D.64. Other collaborative projects with Universities in the USA and Canada have enabled CIMMYT staff to arrange graduate training opportunities for students from developing countries which are relevant to the National Programs of these countries.

### 3.5 Training and Agronomy by CIMMYT in Mexico

D.65. Most of the training by the Maize Program is conducted in Mexico. The training opportunities include in-service training programs and positions as visiting and associate scientists, predoctoral fellows and postdoctoral fellows.

D.66. The in-service training programs are designed to develop the motivation of young scientists within a multi-disciplinary setting, increase technical knowledge and skills in maize crop improvement and production research, teach the steps and principles involved in selecting research objectives and in the design and execution of field experiments, and teach procedures for developing production recommendations suitable for farmers.

D.67. There are four in-service training courses: production agronomy, maize improvement, laboratory analysis, and experiment station management. The courses on maize improvement and production have a duration of approximately six months. The philosophy on which these courses are based, except for laboratory analysis, is to try to complement the lessons learned in traditional agricultural universities or colleges by providing experience in field research and the application of scientific technology to the real problems of farmers.

D.68. Over 600 trainees from 61 countries have completed the in-service training course during its operational period of eleven years. In 1981, trainees from 20 countries participated in one of the four in-service training programs. Of these, 34 participated in the production agronomy course, 11 in the maize improvement course, 5 in experiment station management, and 3 in protein quality laboratory training.

D.69. During the past five years 125 visiting and associate scientists have come to CIMMYT on special travel grants for periods from a week to a year. This has provided continuing training and education to senior National Program scientists and has enriched the intellectual environment at CIMMYT.

D.70. Predoctoral fellowships have provided a limited number of thesis research opportunities under CIMMYT supervision. For example, during 1981 and 1982, with outside financial sponsorship, CIMMYT is cooperating in the education of six master's degree candidates from El Salvador, Ghana, Honduras, Panama and Zaire. In addition, one Ph.D. student from the USA is conducting thesis research in Mexico. During the last five years, 33 students, who were mainly from developing countries, conducted thesis research under the supervision of the Maize Program at CIMMYT.

D.71. Postdoctoral fellowships have provided a limited number of opportunities for young Ph.Ds to spend from one to two postdoctoral years in Mexico in maize crop research and production. Postdoctoral fellows are recruited and trained to provide a pool of suitable candidates for international staff positions. Some postdoctoral fellows have significant responsibilities within the Maize Program, e.g., the Wide-Cross Unit is under the supervision of a postdoctoral fellow. During the last five years, 18 postdoctoral fellows have worked at CIMMYT, 6 are currently at CIMMYT, 5 are working for CIMMYT in various National and Regional Programs, and 5 are working for other international development organizations.

D.72. Agronomy research by headquarters staff of the CIMMYT Maize Program is conducted at a relatively low level of activity, and is mainly designed to complement the in-service training programs.

### 3.6 Communications

D.73. Brief comments are provided which are specific to the Maize Program because this topic is covered in Chapter F.

D.74. Since 1975, Maize Program scientists published approximately 27 scientific papers in journals and books. However, few papers have been published in refereed international journals to provide an explanation and an analysis of the Maize Breeding Program to other scientists and maize breeders. The Panel understands that CIMMYT staff are preparing papers on this topic at this time.

D.75. A field guide for identifying maize diseases was developed in 1978 which has been published in five languages, and has wide distribution in the world. Manuals are being prepared on the identification of insect pests of maize, and on seed production technology. However, few technical manuals have been developed to assist National Program staff in the development of open-pollinated varieties and of various types of hybrids from CIMMYT-origin materials.

D.76. A few materials have been developed to assist the in-service training courses. However, materials that can be taken back home by trainees, so that they can function as trainers, have not been specially developed, except for the field guide for identifying maize diseases.

D.77. Since 1977, seven theses have been prepared by graduate students who were provided guidance by CIMMYT staff.

#### 4. Staffing, Facilities and Budget

D.78. The staffing of the headquarters of the Maize Program consists of essentially one international scientist in each sub-program or discipline, e.g., one breeder in the Advanced Unit, one breeder and one pathologist in the Back-Up Unit, one entomologist and one science writer (part of the communications program) across all subprograms, one breeder in international testing and one breeder in quality protein. In contrast, the training program has three international scientists at this time, but one of these staff mainly serves Regional Programs. Crop physiology is supported by a new associate scientist with a two-year contract from outside sources, and the Wide-Cross Unit is under the supervision of a postdoctoral fellow. Critical support is provided by



five additional postdoctoral fellows with expertise in breeding (3), plant pathology (1) and agronomy (1).

D.79. The staffing of the Regional Programs and Bilateral Programs consists of 11 international staff covering 51 countries in five regions of the world, and one staff in each of three National Programs.

D.80. A complete range of facilities and equipment are available at the headquarters, and at CIMMYT Experiment Stations in Mexico, and they are in excellent condition.

D.81. The 1981 budget appears to have been sufficient for operating the headquarter's and regional maize programs at minimum critical mass levels.

#### 5. Accomplishments of the Maize Program

D.82. The major objective of the Maize Program is to develop germplasm and breeding methods which will enable National Programs to develop improved maize cultivars. One indirect but practical measure of progress with respect to this objective is the extent to which farmers have adopted cultivars with CIMMYT origins.

D.83. The structure of the Maize Breeding Program makes it difficult to estimate the contributions of CIMMYT germplasm to cultivars released by National Programs. CIMMYT has produced 650 experimental varieties for National Programs. It has received reports of 70 varieties, of which about 25% are hybrids, which had CIMMYT origins being named and released by national collaborators in 22 countries. Rough estimates indicate that 30% (2.5 million ha) of the maize producing area of Mexico is planted to CIMMYT-origin materials, whereas as much as 60% (1 million ha) of the maize producing area in other Central American countries is planted to CIMMYT-origin materials. The percentage of the maize producing area

devoted to CIMMYT-origin materials in other regions of the world is generally less than this.<sup>1/</sup>

D.84. The development of experimental varieties by the Maize Program is relatively new. Consequently, the rate of increase in adoption of germ-plasm and methods may also provide a more useful estimate of accomplishments. By this measure, the Maize Program has been successful. More than 70 varieties and hybrids were released in the last three years, a significant increase compared with preceding years. In addition, the number of countries participating in the international trials has doubled in the last five years and includes virtually every maize producing country in the developing world.

D.85. Changes in the scope and effectiveness of sub-programs provides another measure of accomplishments. By this measure, the Maize Program has also been extremely successful.

D.86. The Back-Up Unit has created 13 new pools since 1976, 13 advanced populations have been genetically enriched, and three new populations have been created. An effective shuttle-breeding system has been initiated which is developing pools for the Andean highlands. Several early-maturing pools have been developed which are contributing very useful germplasm to a number of National Programs.

D.87. The Advanced Unit has assembled and classified 24 advanced populations and has initiated cooperation in population improvement with three Regional Programs. Significant progress has been made in developing populations with increased disease and insect resistance, and about 650 experimental varieties have been produced and evaluated over a range of environments. The scope of international testing has substantially increased.

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<sup>1/</sup> Information provided by CIMMYT subsequent to the Review gives an estimate that as much as 5 million hectares in the developing world are now planted to varieties of maize derived from CIMMYT germplasm.

D.88. Significant progress has been made towards developing QPM (Quality Protein Maize) which is suitable for adoption by farmers, and in testing these materials.

D.89. The crop physiology subprogram was particularly successful in laying the foundations for improving yield efficiency, earliness and wider adaptation through plant breeding.

D.90. Significant accomplishments have been made by Regional and Bi-lateral Programs. In particular, work in Guatemala demonstrates that rapid progress can be made in rural development through cooperation between a dedicated National Program and the Maize Program of CIMMYT.

## 6. Future Plans and Constraints

D.91. These future plans are summaries of material provided by CIMMYT Maize Program staff. Two types of plans are indicated, those with previously anticipated funding and those which apply to a reduced funding scenario. Under these two scenarios, CIMMYT has indicated the priority to be given to each activity as follows.

### 6.1 Maize Germplasm Bank

D.92. Anticipated Funding: (Intermediate priority). Collections are not expected to expand significantly, more evaluation and classification work is planned, and greater efforts would be made to identify collaborating institutions for seed regeneration and evaluation.

D.93. Reduced Funding: (Low priority). The germplasm bank would be preserved but the unit would virtually cease regeneration and evaluation. Seed shipments would be significantly reduced.

### 6.2 Wide-Cross Unit

D.94. Anticipated Funding: (Intermediate priority). Collaborate with the University of Illinois on (1) the genetic transfer technique using

germinating pollen in solutions of DNA to facilitate exchange of genetic material between maize and sorghum, Tripsacum and millet, and (2) use two of their Tripsacoid populations for crossing to Maize Program populations. Evaluate progeny for resistance to disease and insects. Continue attempts to overcome sterility in maize x Tripsacum by using maize containing the gametophytic factor and colchicine doubling. Low priority would be given to attempts at normal crossing between maize and sorghum or millet.

D.95. Reduced Funding: (Lower priority). Further limit or discontinue the Wide-Cross Unit.

### 6.3 Germplasm Development

D.96. Anticipated Funding: (High priority). Number of pools are not expected to expand significantly. Emphasis on developing greater disease and insect resistance, especially in earlier maturing germplasm pools. Evaluation of pool materials for heterotic relationships will be continued to support the development of tropical zone hybrids.

D.97. Reduced Funding: (High priority). Current germplasm development work and the number of testing sites used in Mexico would be reduced.

### 6.4 Population Improvement

D.98. High priority activity under all funding scenarios: Emphasis on developing greater disease and insect resistance will be maintained. More populations will be handled through regional bases in collaboration with strong National Programs. Three highland floury populations have just been initiated in Ecuador and they will be improved. Increased support will be given to the design of suitable hybrid development systems for tropical areas.

## 6.5 International Testing

D.99. High priority activity under all funding scenarios: Existing system will continue except that the improvement of some populations, and the preparation of materials for international progeny testing trials, may be transferred to regional bases. A major effort will continue to be mounted to assist National Programs to develop seed multiplication systems.

## 6.6 Nutritional Quality Improvement

D.100. Anticipated Funding: (High priority). Continue to improve breadth of adaptation, yield potential and levels of resistance to ear rots in QPM materials. Develop methods to help in the accumulation of effective genetic modifiers. Develop methods for genetically isolating QPM. Develop six new tropical and four new subtropical advanced populations and subject them to international testing. Become more directly involved in getting superior QPM into farm-level use. Encourage strong National Programs to use QPM materials for the production of hybrids. Continue a modest amount of exploratory research on increases in oil content.

D.101. Reduced Funding: Level of activity would be reduced.

## 6.7 Disease Resistance

D.102. High priority activity under all funding scenarios: Current disease resistance research will continue. Some consideration will be given to development of resistance to late wilt through collaborative research.

## 6.8 Insect Resistance

D.103. High priority activity under all funding scenarios: Current insect resistance research will continue. Some consideration will be given to developing collaborative research projects on resistance to other species of stem borers in other regions. This may require

assisting certain National Programs to develop insect-rearing facilities.

#### 6.9 Crop Physiology

D.104. Anticipated Funding: (Intermediate priority). Continue work on drought resistance and early maturity. Develop a true floury kernel in a temperate plant type for use in tropical highlands.

D.105. Reduced Funding: (Low priority). Discontinue this work.

#### 6.10 Regional Maize Programs

D.106. High priority under all funding scenarios: The East African Regional Program for Maize has just been initiated and it will be given strong support. All Regional Programs will be strengthened to at least the minimum level of two maize scientists with emphasis on agronomy and seed production staff as soon as funds are available.

#### 6.11 Bilateral National Maize Programs

D.107. CIMMYT will provide staff to National Programs in certain cases, such as during the formative stages of a National Program that has made a strong commitment to improve maize production or where a specific research problem can be worked upon that is of benefit to the global maize research network. Special project funding would have to be sought to support the posting of CIMMYT staff to National Programs.

#### 6.12 Maize Training Programs

D.108. High priority under all funding scenarios: In-service training will remain the largest training activity with 50 to 60 trainees per year. More emphasis will be given to seed production issues in training. Increased emphasis will be given to in-country training programs.

## 7. Assessment and Recommendations

### 7.1 General Comments

D.109. The Maize Program has only been operating, in its present structure, since 1973, yet it has made substantial progress in the development of improved germplasm, and in the establishment of a world-wide network of cooperating scientists. The Panel anticipates that further substantial increases in the adoption of CIMMYT-origin cultivars will occur in the near future, provided substantial institutional constraints within developing countries do not impede this progress. Recognizing the important role of maize as a source of food in developing countries, the momentum achieved by the Program, and the substantial opportunities for National Programs to increase maize production, through cooperation with CIMMYT, the Panel recommends that, resources permitting, strong financial support should be provided to the Maize Program.

D.110. The Maize Breeding Program has a simple but effective design which is highly appropriate for an international centre with a global mandate. The Panel recognizes as particularly important, those features of the design which promote the involvement of National Program scientists in both population and varietal development and their close interaction with the scientists of the Maize Program. In addition, the continual production of diverse and broadly adapted germplasm provides breeders in National Programs substantial flexibility in choice of materials and breeding methods. However, emphasis on the development of open-pollinated varieties is a central feature of this design and it is consistent with the needs of many National Programs as determined by the conditions under which they operate. But, the conditions of developing countries, with respect to maize production, are not uniform and should continue to improve. Consequently, a degree of flexibility in breeding is necessary. The Panel recommends that emphasis on development of open-pollinated varieties be maintained but with more work on populations which National Programs can use for developing hybrids as indicated in the future plans of CIMMYT (see sections 6.4 and 6.6 above).

D.111. The Maize Program of CIMMYT has interpreted its mandate, which gives it broad scope, in a valid manner by creating a global network for assisting National Programs to increase the production of maize. The assistance provided by CIMMYT is potentially useful for all developing countries which produce maize. Prior to 1980, the activities of the CIMMYT Maize Program were constrained, in Africa, by the operation of the independent maize breeding program of IITA. Coordination of these programs was partially achieved in 1980 by reorganizing the collaborative CIMMYT-IITA West African Regional Program, and assigning two CIMMYT staff to IITA at Ibadan, Nigeria. However, IITA staff still conduct maize breeding projects at Ibadan and Kamboinse, Upper Volta. The Panel recommends that the value of a completely integrated network for maize breeding, which is directed by CIMMYT, be seriously considered when the future and the relationships of the Maize Programs at CIMMYT and IITA are examined by TAC and other organizations. A precedent has already been set by the arrangements between CIMMYT and CIAT in which CIMMYT staff are posted to CIAT at Cali, Colombia, and operate the maize program while interacting with and obtaining some support from CIAT (also refer to section 5.3.8 in Chapter G for further discussion of possible future collaboration between CIMMYT and IITA).

D.112. The Panel recognizes that the Maize Program is staffed by a team of highly competent and strongly dedicated professionals. However, the design of the Maize Breeding Program is analogous to an assembly line with recurrent feedback cycles. While extremely functional and necessary for the present system, this structure may make it difficult to maintain the morale of the headquarters staff. There are relatively few opportunities for individuals within the system to become identified with, and rewarded for their own specific contributions, and the mutual interdependencies and rigidity of the system reduce the opportunities for innovation. Staff morale can, in the long term, influence the continuity of staffing, and a reasonable degree of continuity is needed if a breeding program is to be successful. Consequently, the Panel recommends that additional mechanisms for maintaining the morale of the staff of the Maize Program should be developed and applied. A possible mechanism is discussed in the following paragraph.



D.113. The Maize Program is large, and the number of plant breeders assigned to it is small. The Panel observed that the requirements of the main breeding program are substantial and leave little opportunity for disciplinary research to increase the efficiency of the breeding program, to appraise genetic advances within the germplasm populations, and to promote the professional development of the staff. The Panel recommends that the Maize Program encourage and reward greater efforts in disciplinary research areas which support the main breeding program. Hiring an additional international scientist at headquarters with responsibilities, within the main breeding program, for maize breeding and quantitative genetics would provide the Maize Program with additional flexibility, and make possible the adjustment of work assignments to give all of the maize scientists the opportunity to pursue some supportive, disciplinary research. Additional strength in quantitative genetics would also substantially assist the maize staff in evaluating and continually improving its Maize Breeding Program.

D.114. The Panel was impressed by the design and accomplishments of the Maize Breeding Program. The Program has a unique approach to breeding; and plant breeders throughout the world would be interested in descriptions and analyses of the Program's methods and results. However, the Panel has the impression that a number of scientists in developed countries do not fully appreciate the value, for developing countries, of the CIMMYT maize breeding approach, and the advances that are being made. Further, the Panel observed that Maize Program staff have not published detailed scientific publications which describe and analyze the methods and results of the Maize Breeding Program. The Panel recommends that the staff of the Maize Program substantially increase their activities in the analysis of the approach and results obtained in the breeding program, and report their findings in refereed journals with wide circulation.

D.115. Seed production is an important constraint confronting attempts to improve maize production. The Maize Program is aware of this problem and has assisted National Programs, e.g. Guatemala, to develop seed production systems. In addition, the Maize Program is developing methods

for maintaining and producing seed of open pollinated varieties. However, contributions are needed from staff in different sub-programs of the Maize Program. The Panel recommends that the Maize Program institute a coordinated effort to assist National Programs to develop seed production systems. This coordinated effort could involve plant breeders, regional and bilateral agronomists and economists, the International Testing Unit, and trainers of CIMMYT working in cooperation with National Program staff.

D.116. The agronomists of the Maize Program are making major contributions to the Regional Programs in cooperation with the economists of CIMMYT. However, their responsibilities are extremely broad. The Panel recommends that attempts be made to better define the responsibilities of the agronomists, in a manner which is more consistent with their professional status as research scientists, and which promotes their interactions with the economists of CIMMYT.

## 7.2 Assessment and Recommendations for the Sub-Programs

### 7.2.1 Germplasm Bank

D.117. The Panel understands that, in the event that there is a shortfall in funds, the Maize Program would virtually cease regeneration and evaluation of materials in the Germplasm Bank. However, since CIMMYT is the major repository of maize germplasm in the world, the Panel recommends that: (i) the efforts of CIMMYT to obtain support from collaborating institutions for regenerating and evaluating germplasm, as described in their future plans (section 6.1 above) should be vigorously pursued; and (ii) the regeneration of seed should continue at a level that maintains the germplasm until alternative arrangements have been made. The Panel further recommends that CIMMYT, IBPGR, and other concerned institutions clarify the assignment of responsibilities with respect to maintaining maize germplasm resources on a worldwide basis, and seek the necessary funds for this work.

### 7.2.2 Wide-Cross Unit

D.118. First priority had been assigned to transferring genes from sorghum to maize. However, there has been no obvious progress using natural crosses. Future plans include trying a genetic engineering technique, and collaboration on genetic mechanisms to attempt to achieve the transfer of genes. The Panel recommends that further attempts to achieve natural crosses between maize and sorghum be assigned low priority, and that a time frame be set after which it should be determined whether this project should be continued at CIMMYT.

D.119. Significant progress has been made with the project for transferring genes from Tripsacum to maize, and other research groups have made progress with this wide cross. The future plans of the Wide-Cross Unit (section 6.2 above) indicate several promising avenues for transferring genes from Tripsacum to populations of the Maize Program, and this would increase the interaction between the Wide Cross-Unit and the Germplasm Development Program. The Panel recommends that the proposed work on transfer of genetic material from Tripsacum to maize be given first priority by the Wide-Cross Unit, and encourages collaboration with scientists at the University of Illinois.

### 7.2.3 Germplasm Development and Population Improvement

D.120. These sub-programs are the back-bone of the Breeding Program and they should be given credit for a major part of the success of the Maize Program. The Panel agrees with the high priority assigned to these programs and their future plans ( see sections 6.3 and 6.4 above).

### 7.2.4 International Testing

D.121. The International Testing Program, as conducted by National Programs, has been expanding and is producing data with substantial intrinsic and unique value. The Panel recommends that this program should carefully examine the possibilities for using the increased capabilities in computing to conduct more comprehensive analyses of the data produced by the international trials.

#### 7.2.5 Nutritional Quality Improvement

D.122. The Quality Protein Maize Program has achieved substantial progress in improving grain-type and yields while maintaining high quality protein, and the Panel recommends that this program should be continued.

D.123. However, the Panel considers that CIMMYT should continue to examine the plans (section 6.6 above) for the evolution of this subprogram. As a possible mechanism for this examination, the Panel recommends that further assessments should be made of the extent to which National Programs are interested in quality protein maize, of predictions concerning the extent of its adoption as a source of livestock feed and human food, and of the breeding methods that are most appropriate for National Programs who wish to develop Quality Protein Maize cultivars. This assessment would provide guidelines concerning the development of new populations, breeding and seed production methods, and the extent of international testing that is needed to meet the future requirements of National Programs.

D.124. The Panel considers that the modest program of exploratory research on oil content in maize has not been adequately justified and recommends that it should be phased out.

#### 7.2.6 Disease and Insect Resistance

D.125. Diseases and insects are major constraints to maize production in developing countries. The Panel commends these sub-programs for their important contributions to the development of populations with resistance to diseases and insects, and agrees with the high priority placed on them by CIMMYT. However, the sub-programs at headquarters, which are working on disease and insect resistance, are completely integrated into the main breeding programs. While recognizing that this is a valid and practical approach, the Panel recommends that consideration be given to increased involvement by international staff and post-doctoral fellows in the development and evaluation of methods for selecting for resistance to diseases and insects, and in mission-oriented, disciplinary research on the pathogens and pests.

#### 7.2.7 Crop Physiology

D.126. The crop physiology program has made important contributions to the Maize Breeding Program in the development and validation of selection criteria for improving the yield efficiency of maize varieties for the lowland tropics. However, methods for selecting for drought resistance have not been adequately analyzed or developed. Drought represents an important environmental stress to both maize and wheat, and a crop physiologist could support breeding programs for both crops. The Panel recommends that the Maize and Wheat Programs pursue mechanisms for maintaining at least one crop physiologist at headquarters on a permanent basis. A crop physiologist with expertise in plant responses to environment, and the chemical and physical environment of the soil, could assist the maize and wheat projects that are seeking resistance to several environmental stresses (i.e. drought, temperature extremes, salinity and excesses or deficiencies of mineral elements in the soil). However, the Panel recommends that methods for selecting for drought resistance should be given first priority by the staff with expertise in crop physiology.

#### 7.2.8 Regional Maize Programs

D.127. The Panel considers that the expansion and activities of the Regional Maize Programs have, in general, made important contributions to the achievement of overall objectives by CIMMYT. With respect to future plans, the Panel agrees with the high priority placed on supporting the new East African Regional Program, on strengthening agronomy and seed production technology, and on maintaining at least two maize scientists in each Regional Program.

#### 7.2.9 Bilateral National Maize Programs

D.128. The Panel considers that the Bilateral National Maize Programs in Guatemala and Ghana have made excellent progress, over a relatively short period of time, in providing improved varieties or hybrids of maize to farmers. The Panel recommends that the Maize Program should continue to be involved in Bilateral National Programs and that it

should follow the guidelines described in its future plans (section 6.11 above).

#### 7.2.10 Maize Training Programs

D.129. The Panel considers that the various training activities of the Maize Program have been, in general, extremely effective in training staff of National Programs. The practical approach of the in-service training, and its underlying philosophy, are consistent with the overall objectives of CIMMYT and the needs of National Programs. Emphasis on on-farm research provides a unique educational opportunity to learn approaches that are key components of the process of rural development; other training programs in the world, frequently, do not provide experience in on-farm research.

D.130. While commending the Maize Training Program for its accomplishments, the Panel recommends that improvements may be made by coordinating the various training programs within the Maize, Wheat and Economics Programs, and by developing more instructional materials for the in-service training courses that deal with maize. This recommendation is further elaborated in Chapter I.

#### 7.2.11 Communications Unit

D.131. In general, insufficient information, in the form of technical manuals, has been published by the Maize Program to assist National Program staff in the use of materials and methods developed by CIMMYT. The Maize Program is already working to solve this problem in that several technical manuals are presently being prepared. In addition, the Panel recommends that the Communications Unit should be provided with more opportunities to assist the Maize Program to develop materials which communicate the practical and scientific findings of the Maize Program to the outside world.

## CHAPTER E

ECONOMICS PROGRAM1. Background

E.1. The Economics Program was established in 1971 with the appointment of the present Director who, since 1978, has been a member of CIMMYT's Directing Staff with the status of an Associate Director. Creation and expansion of the Program have reflected concern about the gap between actual and potential yield levels of maize and wheat in the developing world.

E.2. While the activities of the Economics Program have evolved over the period since 1971, the continuing major focus has been on collaborative study of farm-level production issues relevant to the development and diffusion of improved technologies for maize, wheat, barley and triticale.

E.3. Over the period 1971-76, the Economics Program sponsored a series of studies to identify the factors influencing the adoption of new seed and fertilizer technology for maize and wheat by representative farmers. Maize was studied in Colombia, El Salvador, Kenya and Mexico; wheat in India, Tunisia and Turkey. These studies showed the overriding importance of the agroclimatic and socioeconomic circumstances of farmers in explaining adoption patterns. Where nonadoption occurred, it was usually found that the technology was not consistent with farmer circumstances; that is, adoption was more a function of the characteristics of the technology than characteristics of the farmer such as age, education and extension contacts.

E.4. The adoption studies convinced CIMMYT economists that if agroclimatic regions and the circumstances of representative farmers within these regions could be systematically identified and integrated into research, the chances of developing suitable production technologies would be greatly enhanced. Further, such an approach was seen as facili-

tating the strengthening of national extension programs and assisting governments in fitting research to national priorities. It is these considerations of ensuring the development of suitable maize, wheat, barley and triticale technology for representative farmers and the strengthening of National Programs in this regard that have guided the Economics Program since 1976.

E.5. Particularly over recent years, recognizing that National Programs are responsible for developing improved technologies and formulating recommendations for their farmers, the Economics Program has endeavoured to strengthen its collaborative ties with national researchers, so far as possible in cooperation with scientists from CIMMYT's crop programs. To this end, posting of economists outside Mexico began in 1976 when the headquarters staff of two was no longer able to cope with the consulting demands of national maize and wheat programs. Through 1982, four regional economics programs have been established: Eastern and Southern African in 1976; Andean in 1977; Central American and Caribbean, and South and South East Asian, in 1978. In these regional activities, close collaboration between CIMMYT's regional agronomists and economists was seen as a key feature of CIMMYT's overall strategy. However, due to funding constraints, the deployment of regional agronomists did not proceed to the extent initially planned. In consequence, less collaboration was possible among regional crop program and economics staff than seen as desirable by CIMMYT at large and the Economics Program in particular.

## 2. General Objective

E.6. The general objective of the Economics Program is to assist National Program collaborators in the developing world to develop and transfer improved technology for maize, wheat, barley and triticale. This general objective is broad and of long-term perspective.

## 3. Activities

E.7. To meet its general objective, five sets of inter-related activities are undertaken by the Economics Program. These are (along



with their percentage time allocation averaged across the seven core-supported senior staff):

- (i) Development of research procedures for analyzing the production circumstances of maize and wheat farmers. (35-40%)
- (ii) Training of national collaborators in certain aspects of on-farm research, including survey techniques to assess farmer circumstances and analytical techniques to evaluate agronomic research data related to production recommendations. (35-40%)
- (iii) Compilation and analysis of country-level, regional and global data on maize and wheat production, utilization, prices and trade as a background for CIMMYT's own resource allocation decisions. (5-10%)
- (iv) Collaborative research activities with CIMMYT and National Program scientists - mainly through regional programs - to develop and demonstrate economics-related procedures needed for on-farm research programs. (10-15%)
- (v) Administrative activity including support for the Director General's office. (10-15%)

E.8. Through its activities, the Economics Program aims to maximize the leverage role which CIMMYT can play relative to National Program research expenditures in the developing world of some \$1.25 billion annually. From this perspective, while the CIMMYT economists see their role as no different from that of economists anywhere (viz. data collection and analysis to enable more effective decision making), they see themselves as bringing some particular perceptions that are highly relevant in the research context of CIMMYT and National Programs. To the biological scientists' perception of the natural factors and relationships which affect the production process, the economist is seen as adding an awareness of the need to appreciate the farmer's objectives, alternative resource uses, and considerations that impinge on the farmer's ability to modify current practices. In particular, the insights of the economist into farmer decision making, in terms of tradeoffs and the importance of time and risk considerations in assessing potential investments, are seen as highly relevant to the development of recommendations that are appropriate to farmer circumstances.

E.9. For these economic perspectives to bear grain, the Economics Program sees collaboration among biological scientists and economists in the research process as essential.

#### 4. Staff and Facilities

E.10. Current and planned senior scientist staffing of the Economics Program is as follows:

Responsibility	Funding Source		
	Core unrestricted	Core restricted	Special project
Headquarters	3		
Regional Programs	1 <sup>a</sup>	3 <sup>b</sup>	2 <sup>c</sup>
National Programs			1 <sup>d</sup>

a/ Andean region, currently vacant; perhaps to be transferred to western section of the Asian region.

b/ East and Southern Africa, Asia (perhaps to become East Asia), and Central American and Caribbean; latter located at El Batan.

c/ Appointments anticipated in late 1982 under a two-year special project in East Africa funded by USAID.

d/ Anticipated continuation of existing appointment in Haiti.

E.11. Two 2-year postdoctoral fellows (supported by non-core funds) have worked in the Economics Program over the period 1977-82 and one (supported by core funds) is planned to commence in late 1982. Four pre-doctoral fellows have worked on their thesis research in the program over the same period.

E.12. Facilities available to the Economics Program at El Batan include the services of three research assistants and three secretaries, two

vehicles and an Apple II desk computer. Services from the central computer and library are also available as required. Regional economists generally have a shared or part-time secretary but no research assistants.

## 5. Achievements

E.13. Over the period 1976-82, the Economics Program has been involved in the development of procedures for farm-level research, in training, in data compilation and analysis, in regional activities and in the development of a seminar program for national policy makers. Much has been accomplished in all these areas of activity.

### 5.1 Farm-Level Research Procedures

E.14. This activity has aimed at developing effective procedures for facilitating cooperative research between biological scientists and economists at the farm level. While developed in the context of CIMMYT's mandated crops, the principles and procedures developed are of general relevance in the context of farming systems research.

E.15. Two manuals have been published and a third is in preparation. The first manual, published in 1976, is concerned with the key issues of costs and benefits relevant to a farmer's decisions. Titled From Agronomic Data to Farmer Recommendations, it has become a classic in its area as evidenced by its translation into Arabic, Bengali, Indonesian, Japanese and Turkish at National Program expense and the disbursement by CIMMYT on request of 10,000 copies (four printings) in English, 4,000 copies (two printings) in Spanish and 2,000 copies in French.

E.16. The second manual, published in 1980, is concerned with codifying procedures for the effective conduct of farm-level collaborative research by biological scientists and economists. These guidelines, while featuring close collaboration in all phases of the farm-level research process, see economists as playing the major role in assessing farmer circumstances and biological scientists providing the leadership for on-farm experimentation. Titled Planning Technologies Appropriate to Farmers,

the manual has so far had two printings in English (5,000 copies distributed), one printing in Spanish (2,500 copies), and a French translation is in preparation.

E.17. The procedures outlined in the two published manuals are being used by a growing number of National Programs in Africa, Asia and Latin America in their farm-level research programs. The procedures are also used in CIMMYT's and other training programs.

E.18. The third manual, in preparation, is concerned with procedures for making use of information from farm-level surveys and trials at the national policy-making level. Emphasis is on the development of procedures for use by national policy makers and on giving agricultural researchers an awareness of the connection between their work and public policy.

## 5.2. Training

E.19. Since the appointment of an economics training officer at El Batan in 1979, the Economics Program has contributed substantially to CIMMYT's training effort. Crop program in-service production trainees spend about one-sixth of their stay in Mexico focusing on research procedures to assess the economic aspects of crop production. Trainees are shown how to gather and analyze survey information pertinent for planning on-farm trials, how to analyze on-farm trial results to formulate recommendations, and are given an appreciation of the economic forces that affect agricultural decisions at the farm and national levels.

E.20. Since 1979 the Economics Program has also mounted five three-month training courses for agricultural economists from National Programs with an interest in farm-level maize and wheat research activities. Using a "learning by doing" approach, major focus is on the design, execution and analysis of a farmer survey to provide information to help determine priorities for on-farm experimentation. Twenty five researchers from 13 countries have participated in the course. Initially two courses

per year were provided. This has now been reduced to about one course per year so as to allow additional emphasis to be given to the provision of in-country training.

E.21. In 1981 a new version of the economics course was developed as part of a national in-service training activity in farm-level research. Conducted in collaboration with crop program staff and national collaborators, the course involves a series of "calls" totalling some 12 weeks over a crop production cycle at which trainees are convened at key stages in the research process, beginning with the initial survey sequence and carried on through the planning, execution and analysis of on-farm trials. The first such course was conducted in Venezuela in late 1981 in conjunction with the regional maize staff. This indicated the relative cost-effectiveness of such an approach compared to Mexico-based or regional training. Groups of 20 to 25 trainees can be handled and the national setting ensures training in a context which is highly relevant to National Programs in terms of both staff capabilities and farmer recommendations.

E.22. In addition to contributing to the two manuals so far produced by the Economics Program, and which are used extensively in the Program's training activities, a number of workbooks to accompany the manuals in training have been developed by the economics training officer. Like the manuals, these are proving very efficacious.

E.23. Significant training via workshops and short field courses has also been provided at the national and regional level by CIMMYT's regional economists, particularly in the Andean region for Ecuador, and in the East and Southern African region for Kenya and the region as a whole. For example, by late 1980, 12 Kenyan economists from research stations and some half-dozen Kenyan agronomists had attended one-week training workshops and participated in diagnostic farm surveys. To meet East and Southern African regional demand, it was then decided to broaden the scope of the training to cover both diagnostic survey activities and on-farm experimentation. Workshop time was increased from one to two weeks and, with the assistance of a CIMMYT agronomist, regional

workshops were held in September 1980, April 1981 and June 1982. The April 1981 workshop was attended by 42 participants from ten African countries and included more agronomists than economists; that of June 1982 involved four Kenyan and 28 other participants from 12 countries. Growing out of this activity, the University of Zimbabwe is initiating a sandwich-type course in on-farm farming systems research in January 1983. This course will involve 15 weeks of classroom activity spread over 19 months, the intervening periods being spent on in-service field activities.

### 5.3 Data Compilation and Analysis

E.24. Until 1980, the Economics Program devoted only limited resources to the assembly of production, consumption, trade and price data relevant to CIMMYT's mandated crops. However, in developing the Center's Long Range Plan it became clear that while a considerable quantity of data are available on maize and wheat production, consumption and trade, it is dispersed and not readily available. It also became apparent that some types of information, such as the characterization of maize and wheat production environments in the developing world, were unavailable. Consequently, the Economics Program was charged with building an improved data base for the CIMMYT crops.

E.25. As a start to this activity, two new serial publications were commenced in 1981: World Wheat Facts and Trends and World Maize Facts and Trends. Each includes a tabulation by country of some 30 crop-related statistics and an analysis of global changes in production, consumption, trade and prices over the last two decades. Future two-yearly issues will include updates of the data and will report on selected relevant themes such as national pricing policy, factors affecting the growth of demand for grain, and the role of maize and wheat in the diet of low-income consumers.

E.26. Work has also commenced, in cooperation with National Programs, on the specification of wheat production environments in terms of agro-climatic characteristics, disease stress, type of wheat planted, whether rainfed or irrigated, etc.

E.27. The Economics Program has also carried out a variety of analytical studies covering such topics, for example, as the impact of new wheat varieties on income distribution and the policy issues associated with accelerating wheat production in semi-arid regions. Analyses pertinent to CIMMYT's priorities (e.g., the prospects for triticale) and management (e.g., whether the Mexican peso?) have also been conducted.

#### 5.4 Regional Programs

E.28. In 1981, CIMMYT had four regional economists assigned to as many regions. So far as possible, these economists cooperated with other CIMMYT staff and National Program maize and wheat scientists and economists in the development of technologies for representative farmers. This has involved bringing economists and biologists together in farm-level research, consulting on the organization of such research, providing modest resource support for such research where necessary, and cooperating in analyzing the implications of the research results.

E.29. In the East and Southern African Regional Program, initiated in 1976 with UNDP funding, the regional economist (headquartered in Nairobi) has worked most closely with National Programs in Kenya, Malawi, Zambia and Zimbabwe. A number of training workshops have been conducted. Zambia has institutionalized the CIMMYT Economics Program's on-farm research procedures via a restructuring of the Research Branch of the Zambian Department of Agriculture. This has involved the formation of, on the one hand, Commodity Research Teams based at regional research stations with a responsibility for station-based technical research and, on the other hand, Adaptive Research Planning Teams to carry out on-farm research using CIMMYT methodology in each of Zambia's nine regions. In Zimbabwe, a full demonstration of the Economics Program's survey research procedure was carried out in 1981 and a program of farm experiments based on the survey work has been implemented. Concomitantly, Zimbabwe has decided to build its capacity to do on-farm research within its National Agronomy Institute. The regional economist has also provided considerable consultation to international donor agencies interested in supporting farming systems research. USAID,

commencing late 1982, will fund two further economists in the regional program, one a training officer to be located in Nairobi and the other to be located in Zimbabwe. In this way, USAID hopes to facilitate its substantial array of farming systems research projects in the region.

E.30. From 1977 until mid-1982 (when the position became vacant), an economist was located in the Andean region for collaborative research in Bolivia, Colombia, Ecuador and Peru. This work, headquartered in Quito, concentrated on flourey maize in the highlands, tropical maize in coastal regions, and on wheat and barley in highland farming systems. Within the region, two countries - Ecuador and Peru - have made strong national commitments to on-farm research. Ecuador, with USAID support, has expanded its on-farm research division to serve eight major production regions within the country. A new short-season maize, the need for which was discovered through on-farm research, has been introduced and research stimulated to identify suitable bean varieties for associated cropping with it. In Peru, on-farm research is focused on highland maize production and on wheat production (with CIDA support) in new irrigated coastal areas. Two training sessions were conducted in 1981. These used a "call system" in which participants were convened at critical stages in the crop research cycle. One course focused on wheat production in highland Ecuador and the other on maize production in Venezuela. Headquarters and regional maize, wheat and economics staff participated in giving these courses.

E.31. The regional economist assigned to Central America and the Caribbean since 1978 on Swiss government funding has concentrated his work in El Salvador, Haiti, Honduras and Panama. He is headquartered at El Batan. In Panama, the national agricultural research institute has extended its on-farm research activities to new areas and additional crops. Farm surveys have been conducted to guide research. In 1980, cooperation in farm-level research was initiated with Honduran researchers in collaboration with CIMMYT's regional maize staff. In Haiti, with the posting in 1981 of a postdoctoral fellow in economics, and again with involvement of CIMMYT's maize staff, collaboration in on-farm research has increased. Surveys have been completed in several



areas and a series of on-farm trials established. Some training, involving regional maize and economics staff, has also been initiated.

E.32. The South and Southeast Asian regional economist, based in Bangkok since 1979 (the incumbent changed in mid-1982), assisted maize and wheat researchers in Bangladesh, Indonesia, Nepal, the Philippines and Thailand. During 1978, when the regional program was based in New Delhi, collaboration with India and Pakistan in on-farm research related to triticale production in the Himalayas was undertaken. Work in Indonesia has concentrated on maize production in East Java and has shown the overriding importance of short-season maize varieties for the region. Survey research has also been undertaken in Nepal and Thailand on maize production, and assistance given to the initiation of on-farm trials. Some attention was also given to on-farm wheat research in Thailand, Bangladesh and the Philippines in collaboration with National Programs.

#### 5.5 Seminars for Policy Makers

E.33. Using specially developed case study materials, a total of five four-day management seminars for public decision makers were held during 1979-81 in Bangladesh, Colombia, the Dominican Republic, Kenya and the Philippines. Support was from a UNDP special project grant. Cases addressed themes related to the orientation of agricultural research, seed production and distribution, fertilizer distribution and crop marketing. This activity has now been transferred to ISNAR with whom CIMMYT plans to cooperate in the further development of case materials.

#### 6. Constraints and Other Considerations

E.34. The Economics Program faces five significant constraints or constraint-like considerations in its work. Primary among these, though it might not be perceived as a constraint from within the Center, is CIMMYT's emphasis on germplasm development as the means sine qua non of meeting its mandate. In consequence, CIMMYT has two major programs (Maize and Wheat); and Economics, as a minor third program, is constrained in its role and influence. In this context, the Economics

Program's role has been seen to be to concentrate on farm-level research and training relevant to CIMMYT's mandated crops, and to pursue these activities in collaboration with the Center's crop scientists, particularly agronomists, so as to maximize CIMMYT's overall research productivity. From this has arisen the second significant constraint facing the Economics Program, viz. budget constraints have curtailed the appointment of regional agronomists so that it has not been feasible for regional economists to always work to the desired extent with a CIMMYT agronomist.

E.35. The third significant consideration also arises from the focus of the Economics Program, though it is more a problem to overcome than an immutable barrier. The difficulty is the traditional disciplinary-based form of organization (reflecting a reductionist research philosophy) which is often, if not generally, found in national agricultural research organizations. To achieve acceptance and implementation of a systems approach to research in such organizations is not easy.

E.36. The fourth (and rather peculiar) constraint faced by the Economics Program is the pressure placed upon it both directly in terms of consultancy demands and indirectly in terms of "parental responsibility" by the enthusiasm with which some aid donors have provided substantial bilateral funding for the development of on-farm research programs in many developing countries, particularly in Latin America and Eastern Africa.

E.37. A fifth constraint, not unrelated to the first, is the small number of research assistants (three at El Batan) available to the Program.

## 7. Future Plans

E.38. The Economics Program's plans for the period 1982-87 do not envision any major change in the direction of its activities. The major focus will continue to be at the farm level with National Programs as clients.

E.39. Continued development of farm-level research procedures is seen as a high priority activity under all funding scenarios. Should serious funding shortfalls occur, a cutback would be made in training and in data compilation and analysis activities. Under current budget constraints, filling of the Andean regional economist position, vacant since mid-1982, is being reassessed in terms of the possibility of transferring the position to the South and Southeast Asian region, thereby complementing the position located in Bangkok with one in Pakistan.

E.40. Relative to the development of on-farm research procedures, emphasis will be given to studying the process of institutionalizing these procedures within National Programs. Procedures will also be developed to aggregate, analyze and present information generated by on-farm surveys and trials for use by national policy makers.

E.41. In the area of training, consideration is being given to the provision of short courses for developing-country economists on the analysis of secondary data and the pre-screening of technological components for on-farm trials. The addition of a postdoctoral fellow is planned to increase the effectiveness of the Economics Program's contribution to the maize and wheat in-service training programs in Mexico. Considerably more emphasis is also proposed on national in-country training activities in on-farm research in collaboration with Maize and Wheat Program staff. Work will also continue to develop additional workbooks and other teaching materials to supplement the field experiences of the various on-farm training courses.

E.42. Data analysis is to be extended to include more analytical work on specific policy and welfare issues related to maize and wheat production, trade and consumption.

E.43. Increased activity is planned in regional programs to support in-country training in on-farm research in collaboration with other economics and crop program staff; to help institutionalize on-farm research in National Programs; and to develop micro policy-level research procedures in collaboration with selected National Programs.

## 8. Assessment and Recommendations

E.44. The Panel recognizes that the Economics Program is staffed by a team of highly competent and strongly dedicated professionals. Subject to the comments made below, the Panel agrees with the general focus of the Program's activities. In particular, the Panel notes that over the last six years, CIMMYT's team of economists has made major contributions both directly and through their extensive publications (a) to the development and institutionalization of farm-level elements of farming systems research procedures for National Programs in developing countries, (b) to CIMMYT's training programs, (c) to understanding of the global and regional pattern of production, trade and utilization of maize and wheat, and (d) to better understanding by developing-country policy makers of the constraints faced in agriculture's development.

E.45. The Panel sees some difficulties, however, in the operation of the Program - difficulties which arise in the main from the constraints (exogenous to the Program but in part endogenous to CIMMYT) outlined in section 6 above. As discussed below, the effect of these constraints, to a greater or lesser degree, is to be seen in the various activities of the Program. Since most of these constraints are not likely to be overcome in the next five years, the approach taken here by the Panel is to consider means by which their effects may be alleviated.

### 8.1 Staffing

E.46. The Panel was pleased to note that in 1982, for the first time, a core-supported postdoctoral fellow has been allocated to the Economics Program.

E.47. It was apparent to the Panel that the provision of additional research assistants would greatly enhance the work capacity of the Economics Program. Currently, the Program is working at full capacity. Additional research assistants would enable the senior staff to undertake a variety of additional projects, particularly as suggested below in the areas of data compilation and analysis which are highly relevant to CIMMYT's priority setting.

E.48. The Panel recommends that under the current level of funding there be no change in the number of core-supported senior economist positions but that consideration be given to the addition of at least two research assistants with appropriate qualifications in economics; as appropriate, additional senior economist positions might be obtained via special projects.

## 8.2 Characterization of Maize and Wheat Production Areas

E.49. Despite continuing efforts by the Economics Program to initiate work on the characterization of the developing world's maize and wheat production areas in terms of agroclimatic, socioeconomic and other relevant parameters, the Panel was dismayed to find this had not yet been done. It is apparent that CIMMYT has given insufficient priority to this task. In the view of the Panel, such information is essential both to CIMMYT's own setting of priorities and to outside appraisal of those priorities. The Panel commends the Economics Program for its attempts to initiate such work and is pleased to note that such work has in fact now begun for wheat.

E.50. The Panel recommends that, as a collaborative project between the Economics Program and the crop programs, high priority be given to completion of the characterization of production zones in terms of key agroclimatic, socioeconomic and other relevant variables for both maize and wheat, making use as required of fixed-term collaborative inputs from specialists in such relevant disciplines as agroclimatology.

## 8.3 Maize and Wheat Facts and Trends and Their Analysis

E.51. The Panel commends the Economics Program's initiation of the serial publications respectively covering world facts and trends in maize and wheat. It sees great value in the proposed analysis in these publications of selected themes related to maize and wheat supply and demand.

E.52. It would appear that in the past the Economics Program has been somewhat hesitant about engaging in macro policy studies of a global or regional nature relevant to CIMMYT's mandate, in part because studies of this type were seen as the prerogative or responsibility of other institutions, such as the Stanford Food Research Institute and IFPRI. However, the Panel sees such studies as being of importance to CIMMYT in its priority setting and also as an element of CIMMYT's responsibility under its mandate. In particular, there is a need for demand studies of the world grain market in relation to the impact of end-use changes (especially increased demands for livestock feed) on world grain prices and their consequent effect on developing countries.

E.53. The Panel recommends that macro studies relevant to CIMMYT's mandate be included as normal elements of the portfolio of activities of the Economics Program either directly, or as appropriate, via collaborative studies with relevant institutions. In this context, the Panel also sees a necessity for the Economics Program to keep abreast, possibly via liaison with other institutions, of trends in other commodities such as sorghum which may be relevant as substitutes in production or consumption for CIMMYT's commodities.

#### 8.4 Contribution to CIMMYT's Choice of Priorities

E.54. The Panel gained the impression that greater use could be made of the Economics Program's expertise so as to provide information relevant to CIMMYT's choice of priorities by bringing economic analysis to bear on the choices available. In this regard, the Panel sees the above-recommended work on characterization of maize and wheat production zones and macro studies of wheat and maize and the world grain market as particularly relevant to CIMMYT's setting of priorities.

E.55. The Panel recommends that CIMMYT make use of its Economics Program to provide information relevant to choice of the Center's priorities and its allocation of resources between and within Programs and regions by Center Management and the Board of Trustees.

### 8.5 Monitoring of CIMMYT's Impact

E.56. Insofar as CIMMYT's major final product is the adoption of improved germplasm by farmers via National Programs, the Panel recommends that the Economics Program, either directly or by facilitating the work of others, ensure a monitoring of the use and effect on production of CIMMYT-influenced germplasm around the world.

### 8.6 Training

E.57. The Economics Program has made a significant contribution to CIMMYT's training activities via both its own training course and its input to the production agronomy courses of the Maize and Wheat Programs. In particular, the Panel commends the Program's development and provision of training manuals and workbooks appropriate to its training activities.

E.58. At a higher level of training, the Panel also commends the Economics Program for its successful development and initiation during the last quinquennium of special seminars for developing-country policy makers. The Panel agrees with CIMMYT's decision to pass this activity to ISNAR.

### 8.7. Inter-Program Collaboration

E.59. While many instances of excellent collaboration between CIMMYT's economists and crop scientists, particularly agronomists, were evident to the Panel, there is a need for a more complete degree of collaboration. In particular, the existence of strong collaborative relationships between economists and agronomists in on-farm research and development must be seen as a necessary condition for the success of such an activity.

E.60. The greatest difficulty in achieving the desired level of association between CIMMYT's agronomists and economists was apparent in some regional programs relative to the development of on-farm research pro-

cedures and their institutionalization. At base, the difficulty is caused by differences in regional priorities between Programs and the apparent lack of a mechanism to determine and ensure a coordinated set of priorities for the Center as a whole across its three Programs.

E.61. In the view of the Panel, it would be highly desirable for out-posted economists to be located in association with a CIMMYT agronomist. Though this has generally been the case - the Andean and the East and Southern African regional programs being the major exceptions - it is not guaranteed by current organizational arrangements. Achieving such an association is also likely to be made more difficult by budget restrictions.

E.62. Recognizing this problem, and also the uniqueness of the Economics Program as a disciplinary unit beside the two commodity-based programs, the Panel gave serious consideration to alternative organizational structures which might alleviate the problem. Among many, these alternatives included, for example, the following possible ways of structuring CIMMYT:

Model A: Maize and Wheat Breeding Programs (staffed by breeders and pathologists) plus a single Crop Production Program (staffed by physiologists, agronomists and economists).

Model B: Maize and Wheat Programs (as at present but including economists) plus a small Economics Unit concerned with macro studies.

Model C: Disciplinary Departments of Plant Breeding, Pathology, Physiology, Agronomy, Economics, etc. interacting via multidisciplinary project teams.

E.63. Relative solely to the question of the location of economists within CIMMYT, the Panel saw merit in Model A. However, recognizing that the incumbency of four out of the eight directing staff has changed since the last Quinquennial Review, and also influenced by the strong desirability of maintaining economics as a disciplinary unit for reasons



of professional orientation and efficiency, the Panel judges that there would be at present no net benefit in such restructuring.

E.64. To facilitate a more complete degree of collaboration, the Panel recommends (a) that Management continue to pursue mechanisms aimed at enhancing collaboration, (b) that no economist be posted to a regional or national program unless there is a good possibility of collaboration with a competent agronomist, preferably from CIMMYT or another Center, and (c) that there be interaction between the Economics Program and the crop Programs in the determination of regional and country priorities in order to ensure, so far as possible, association between economists and agronomists.

#### 8.8 Institutionalization of On-Farm Research

E.65. Through its regional activities, the Economics Program has played a very significant catalytic role in stimulating the institutionalization of on-farm research in a number of National Programs, particularly in Latin America and East Africa. In consequence, for the first time in many of these countries, research is being focused with an awareness of farmers' circumstances and needs, and a bridge is available for the better linkage of experiment station research and extension.

E.66. The Panel, however, wishes to note a potential danger in such institutionalization of on-farm research in developing countries. The danger is that, because of the difficulty of modifying the attitudes and modus operandi of the established research organization, a new research department may be set up which is not sufficiently integrated in its activities with those of either the existing more traditional research departments or with the extension department of the National Program. At the extreme, the danger is that such a new department responsible for on-farm research may operate completely independently of experiment station and other traditional research, and may take over and supplant the role of extension. If this were to happen, not only would the National Program be ill-served per se, but difficulties could be caused for CIMMYT in its relations with the National Program. The latter could

also occur through premature or overforceful attempts to have a National Program initiate on-farm research.

E.67. Though recognized by the Economics Program, this possible danger of insufficient integration of on-farm research with experiment station research and extension is - in the view of the Panel - not sufficiently stressed in the Program's publications. To minimize the danger, it would seem necessary from the start to have a degree of direct involvement of both extension and experiment station personnel in on-farm research activities. Currently neither the participation of extension or station-based research personnel in on-farm research is strongly stressed in Program material.

E.68. The Panel recommends that, in this work oriented to the institutionalization of on-farm research in National Programs, the Economics Program pay special attention to the possible danger of insufficient integration between, on the one hand, on-farm research and extension and, on the other hand, on-farm research and experiment station research. The Panel also notes that this danger may be exacerbated by aid donor enthusiasm for the initiation of on-farm research in developing countries. It is hoped that CIMMYT may be able to help ensure that such enthusiasm is not misdirected. In this context, the Panel is pleased to note the Economics Program's planned involvement in an advisory-type role to a series of bilateral farming systems projects for nine countries in Eastern and Southern Africa. For the best chance of success in this project, however, it sees as essential the placement of a CIMMYT agronomist in the region as is currently planned. More generally, the Panel sees the association of a CIMMYT agronomist with an economist as ensuring both better rapport with biological scientists in National Programs and facilitating their adoption of on-farm research in a way which will help overcome the dangers alluded to above.

### 8.9 Implementation of On-Farm Research

E.69. Apart from the problems of institutionalizing on-farm research, the Economics Program and CIMMYT at large face a problem in promoting such research. The difficulty lies in the fact that CIMMYT's mandate relates to maize and wheat while on-farm research is an element of farming systems research. In so far as farming systems research implies a view of the farming system as a whole, there is an inconsistency in any concentration on maize or wheat without balanced regard for other elements, whether crops or animals, in the farming system. Further, any such emphasis on a particular element in the system without due regard for other elements of the system, may not be in the best interests of the farmer. To the extent that maize or wheat may be dominant enterprises in a given farming system, this danger will be lessened. Too, maize or wheat may be taken as the entry points to the analysis of farming systems and used to exemplify principles pertinent to the analysis and appraisal of other enterprises in the system and the analysis of the overall system. The Panel was informed that the latter approach was taken by the Economics Program in its on-farm research activities whether at the level of training or in the collaborative demonstration work with National Programs. The Panel suggests that this orientation should be maintained, particularly as the Economics Program is playing a leading role in the development of on-farm research procedures and hence contributing significantly to the overall development of farming systems research methodology.

E.70. The paradox of developing farming systems research from a mandate for particular crops does, however, raise a broader question. This is whether it might not be more appropriate for such work to be pursued by relevant Centers with an agroclimatic or farming systems mandate rather than a commodity mandate. Since this is a question with implications across the CGIAR system, the Panel wishes to do no more than raise it. At the very least, however, and as has been fostered by a number of workshops sponsored by CIMMYT's Economics Program, the Panel sees it as highly desirable that there be continual sharing of experience and cooperation between those Centers involved in on-farm and other types of

farming systems research. The Panel recommends that the Economics Program continue to sponsor such liaison opportunities.

#### 8.10 Policy Implications from On-Farm Research

E.71. Too often agricultural policies in the developing countries are developed in ignorance of the circumstances of representative farmers, their actual production capabilities and their research needs. The results of on-farm research provide a means of overcoming this deficiency in the policy making progress. The Panel records its approval for the Economics Program's plans to develop procedures for facilitating the use of on-farm research results in policy making and appraisal, and endorses its recognition that CIMMYT should itself not become involved in national policy making.

## CHAPTER F

SUPPORTIVE DISCIPLINARY RESEARCH AND SERVICES1. Introduction

F.1. CIMMYT has taken a pragmatic approach to science in pursuing its objectives since its inception in 1966, and this approach has been endorsed by several previous review panels. However, as the world changes, the approaches and methods used by CIMMYT should evolve to adjust to these changes. This issue is examined in considering the supportive disciplinary research activities at headquarters.

F.2. In addition, supportive services are examined in this chapter from the standpoint of their effectiveness in contributing to the Maize, Wheat and Economics Programs, and the achievement of overall objectives by CIMMYT.

2. Supportive Disciplinary Research at Headquarters and Collaborative Research2.1 Supportive Disciplinary Research at Headquarters

F.3. Despite its endorsement of CIMMYT's pragmatic approach to science, the first quinquennial review asked "where the next advance in productivity is to come from" and answered "it seems likely that some form of plant physiology, pathology or genetics, might be most helpful in the longer term."

F.4. The present Panel agrees with these observations. Except for staff in the Wide-Cross Units and crop physiology, CIMMYT staff appear to have devoted little time to disciplinary research, as judged by the relatively small number of scientific publications in refereed journals. The Panel considers that with the strengthening of National Programs, CIMMYT should begin to devote more effort to disciplinary research so as to

provide the new types of genetic materials and methods that these more advanced National Programs will need.

F.5. In this section it seems appropriate to discuss the principles governing the choice and extent of supportive research at headquarters, and not the disciplinary details which are covered in the separate sections, to guide the anticipated long-term evolution towards greater involvement in disciplinary research.

F.6. The professional development of international staff and continuity of staffing, which strongly determine the success of IARCs, would be promoted by a system which encourages international staff to devote a proportion of their time to supportive, disciplinary research. In this way staff members would be conversant with the current scientific literature, maintain contact with scientific peers, and continue to develop as disciplinary scientists. The area of the disciplinary research should be chosen so that it complements the mission-oriented activities of the staff member. In this way it would, in the long term, contribute to the evolution of the IARC and attainment of overall objectives.

F.7. The alternative model, which has been adopted by CIMMYT and several other IARCs, is to devote a few positions mainly to disciplinary research. The danger in this approach is that the disciplinary scientists may become isolated from their colleagues who are mainly doing mission-oriented research. In this case, the interactions between the disciplinary and mission-oriented scientists are limited, and two classes of international staff are created. This can lead to dissatisfaction among individual staff, the appearance of unequal treatment or not fitting in to the general scheme of things, and it may harm staff morale.

## 2.2 Collaborative Research

F.8. IARCs frequently engage in collaborative research with National Programs in developing countries with the aim of finding solutions to

problems of general interest to the IARCs but which are of special importance to the particular developing country. This type of research has been discussed in the chapters on the various Programs.

F.9. Collaborative research can also provide mechanisms for stimulating disciplinary research in directions which support the long-term objectives of IARCs, at relatively small cost to the IARCs.

F.10. The role of collaborative research in IARCs was discussed in the "Report on the Stripe Analysis of the Off-Campus Activities of the International Agricultural Research Centres," (TAC Secretariat, June 1980, paras. 107 to 112). This report suggested that, only on very rare occasions, could the use of core funds be justified for collaborative research projects. In addition, it suggested that the initiative for starting projects should come from the IARC after joint discussions with possible cooperating institutions. The present Panel agrees with these suggestions, and suggests some additional guidance concerning approaches to collaborative research.

F.11. Collaborative research in IARCs has multiple functions in addition to providing links in an international network of activities.

- (1) It can provide scientific expertise, facilities, equipment, environmental conditions and scientific information that cannot be obtained within the system of the IARC.
- (2) It can contribute to the professional development of international staff in the IARC and to the scientific reputation of the IARC as a whole.
- (3) Collaborative research is frequently conducted between an IARC and a center of excellence in the developed world, and this provides a mechanism for IARC scientists to transmit useful information between scientists in technically developed and developing countries.

F.12. There are also some dangers associated with collaborative research. The potential direct contributions of collaborative research to the overall objectives of the IARCs are uncertain and frequently

long term in nature. Inappropriate collaborative research could waste IARC resources, in terms of staff time and travel costs, and damage the reputation of the IARC. The main advantages of collaborative research to IARCs can only be achieved if the project is carefully chosen and designed, and if there is reasonably close collaboration among project scientists. This requires that the IARC must be prepared to commit adequate levels of staff time and travel funds to each collaborative research project.

F.13. CIMMYT has a substantial number of collaborative research projects with technically developed countries at this time. The Wheat Program is involved in 29 projects, the Maize Program has 10, the Economics Program is collaborating with IFPRI and ISNAR, and the Support Services Unit is cooperating with Agriculture Canada in the use of the new computer, and with the Commonwealth Agricultural Bureaux on information services.

F.14. The Panel did not have the opportunity to conduct a comprehensive analysis of the extent and quality of collaboration in different projects. Three Panel members did, however, evaluate the collaborative project with Oregon State University on spring x winter wheat crosses. The Panel members reported that "the cooperation .... is effective, fruitful and mutually beneficial. As a result of this cooperation, significant advances were made in the improvement of both winter wheats and spring wheats for developing countries."

F.15. It is noteworthy that 60 percent of the current collaborative research projects were initiated since 1976, and that many of the new projects emphasize supportive, disciplinary research.

### 2.3 Assessment and Recommendations

F.16. There is a future need for a higher level of supportive disciplinary research at CIMMYT headquarters if it is to evolve to address the changes that will occur in the world. The Panel recommends that emphasis be given to the model in which international research staff are encouraged to devote a proportion of their time to supportive



disciplinary research. In the rare cases where a position is devoted to an area which mainly involves disciplinary research, the responsibilities and activities of the position should be designed to promote an adequate level of interaction with the mission-oriented programs.

F.17. Collaborative research projects represent a major opportunity to provide the mission-oriented research projects of CIMMYT with supportive, disciplinary research. The Panel recommends that the present vigorous pursuit of collaborative research projects, that emphasize supportive, disciplinary research which is consistent with the long-term goals of CIMMYT, should be continued. However, the projects should be carefully chosen and designed. The Panel suggests the following guidelines concerning collaborative research projects (other than those designed to provide a link in the international network).

- (1) They should be fully supported by the CIMMYT scientist who has the main responsibility for collaboration.
- (2) They should be sufficiently substantive and supportive of CIMMYT mission-oriented programs to warrant provision of adequate CIMMYT staff time and travel funds to make the project truly collaborative.
- (3) The Project should be terminated, within a reasonable time frame, if it is clearly established that the project no longer contributes to CIMMYT programs or, alternatively, collaborative projects should have a fixed time period, and require periodic renewal.

F.18. The commodity-based structure of CIMMYT will tend to impede disciplinary interaction between Programs and the effective use of disciplinary input from collaborative research projects. A mechanism is needed to coordinate the supportive, disciplinary research and collaborative research projects. The Panel recommends that the Deputy Director General for Research at CIMMYT be responsible for coordinating disciplinary and collaborative research at headquarters. The Deputy Director General should promote appropriate disciplinary and collaborative research, develop mechanisms for linking disciplinary and collaborative research across CIMMYT Programs, and ensure that the total

program of collaborative research is coordinated and consistent with the objectives of CIMMYT.

### 3. Laboratory Services

#### 3.1 Background

F.19. Since its inception, CIMMYT has established a relatively small but vital laboratory facility as a supporting service to the Wheat and Maize Programs at headquarters. This facility has not grown much in size over the years but various improvements have been made from time to time in order to cope with the increasing demand of the Wheat and Maize Programs.

#### 3.2 General Objectives

F.20. The main objectives of the Laboratory Services as stated by CIMMYT are:

- (1) to provide data on protein quality and quantity in maize and wheat as requested by the crop programs to enable breeders to make appropriate decisions in varietal crossing and selection.
- (2) to provide tissue and soil analyses for the crop programs and the monitoring of soils and fertilizer applications in experiment stations.
- (3) to monitor the chemical quality of water used in irrigating experiments and to coordinate periodic biological checks on the potable water at CIMMYT facilities.
- (4) to assist wheat breeders in screening seedlings for tolerance to aluminum toxicity.

#### 3.3 Organization and Procedures

F.21. Laboratory Services are organized in two main sections. One section is concerned with the evaluation of the qualities of wheat, barley and triticale, in terms of milling and baking and other aspects of food preparation. The other section comprises three main laboratories

which specialize in protein analysis, soil and water analysis, and screening for aluminum toxicity. These two sections operate independently under international scientists, but their operations are fully integrated with the crop programs. In addition to these laboratories, there are pathology and insect-rearing laboratories and greenhouses which are under the management of scientific staff in crop programs.

### 3.4 Staffing, Equipment and Facilities

F.22. There are 24 technicians employed in Laboratory Services comprising 4 in the milling/baking quality laboratory, 11 in protein quality, 3 in soil and water analysis, and 6 in the pathology/entomology facilities. The laboratories are quite well equipped and a highly qualified associate scientist has been able to keep the equipment in good working order. No major problems of supplies are experienced and the operations are smooth and efficient. The average total budget for the laboratory services over the last five years has been approximately US\$ 465,000 (in 1982 dollars) and is not expected to increase substantially in the near future.

### 3.5 Accomplishments

F.23. The milling/baking quality laboratory has been invaluable in the maintenance and improvement of these qualities in new varieties of wheat which have been bred for higher yields and better agronomic characters. The laboratory has proved particularly useful in the development of triticale which has now approached wheat not only in yields but also in the quality of bread and other popular food preparations that can be made from triticale, such as cakes, biscuits, chappati and tortillas. Various mixtures of maize and wheat have also been investigated in terms of breadmaking. In these tests 10% maize-90% wheat mixtures have proved quite satisfactory.

F.24. The protein quality laboratory has the highest proportion of Laboratory Services staff resources. The laboratory analyzes

approximately 22,000 samples of cereal grain every year, 85% of which are in support of the Quality Protein Maize breeding program. This laboratory operates under heavy pressure in order to provide timely data for use in various crossing programs and has made significant contributions in the development of rapid analytical techniques for handling large numbers of samples. Simple techniques are used for initial screening of materials, which facilitate accurate determinations on fewer samples without loss of vital information. The emphasis in these analyses is on both total nitrogen content and the quality of the protein in terms of tryptophan and lysine content. Analyses of oil content in maize are also carried out as part of the overall improvement of nutritional quality in maize. This facility has provided essential assistance to the Maize Program in developing high quality protein maize with good yield and agronomic characteristics.

F.25. The soil and water quality laboratory has also provided valuable service to the Station Management Unit, which has the responsibility of ensuring that the very intensive use of land under irrigation by breeders does not lead to serious problems of soil fertility. It is important to note in this respect that efficiency in varietal selections under field conditions depends highly on uniformity of soil fertility within breeding plots. In consequence, the role of the soils laboratory will become increasingly important since rotational systems are difficult to apply in CIMMYT's station lands due to limited land area.

F.26. Substantial progress has been made in the third laboratory of the laboratory services unit in the development of techniques for screening large numbers of wheat plants for tolerance to aluminum. Single plants from numerous crosses are germinated in a suitably buffered solution of aluminum chloride and observations made on root elongation. Using this system, the laboratory handles 26,000 plants in a year. Plants showing tolerance are grown in the glasshouse and finally multiplied in the field. Methods are also being developed for tests of manganese toxicity in wheat.

F.27. The pathology and insect-rearing laboratories have also been instrumental in providing inoculum and mass rearing of insect pests which are subsequently used in challenging new varieties under field conditions.

F.28. The Laboratory Services at CIMMYT have also made a significant contribution in the field of training. In the last five years, 31 trainees and visiting scientists from collaborative programs in developing countries have benefitted from training in analytical techniques in the complex areas of protein quality and the evaluation of milling and baking qualities in wheat. Trainees in maize quality technology usually spend one to three months at CIMMYT. These trainees either come from an established laboratory or they will establish such a laboratory on their return. Thirty-six trainees and visiting scientists have similarly benefitted from the pathology and entomology laboratories.

### 3.6 Assessment and Recommendations

F.29. Laboratory Services in CIMMYT are an essential component of the crop improvement programs and must be maintained. Sound procedures have been developed to deal with current requirements of the breeding programs and there is no immediate need to increase the capacity. It is, however, necessary to continually review the role of the laboratories in supporting plant physiology and soil chemistry, e.g., by analyses of the mineral elements in plants and soils in relation to nutritional imbalances and toxicities. If these services expand, CIMMYT will need a plant physiologist or a soil chemist to interpret these data. This could be achieved through collaboration with specialized laboratories in developed countries. Although training is not described by CIMMYT as a major objective of Laboratory Services, it is an important function which should be maintained. Trainees in production programs should also be encouraged to participate in laboratory analyses and the interpretation of the ensuing data from their field experiments.

F.30. The Panel recommends that Laboratory Services at the headquarters be maintained and that the work on aluminum toxicity be extended to cover some limited aspects of soil salinity. Research on composite flours involving wheat, maize and triticale are of interest to many developing countries which cannot reach self-sufficiency in wheat production, and should therefore be maintained and the results publicized.

#### 4. Data Processing

##### 4.1 Background

F.31. Prior to 1976, CIMMYT did not have an in-house data processing facility but relied upon the services of the computer of the National School of Agriculture at Chapingo. The installation of a NOVA computer in 1976 provided CIMMYT with an in-house data processing facility. Despite the addition of a second NOVA, it soon became apparent that the increase in demand had exceeded the capacity of the system.

F.32. In 1981, CIMMYT conducted a thorough review of its Data Processing Services with the assistance of an external consultant. This review relied heavily on an earlier detailed study conducted by the Laboratory for Information and Sciences in Agriculture, Colorado, USA, in 1979. As a consequence of this review, a VAX 11/780 computer was installed in March 1982. At the time of the Panel's visit, CIMMYT was in the process of bringing the new computer system into full operation.

##### 4.2 General Objectives

F.33. The general objectives of the Data Processing Unit as stated by CIMMYT are:

- (1) to provide an efficient and timely data processing service to the Maize, Wheat and Economics Programs.
- (2) to develop continuously more efficient computer programs for CIMMYT, and to assist in improving experimental design and statistical analysis to allow a more comprehensive interpretation of results.

##### 4.3 Organization and Procedures

F.34. A multiuser VAX 11/780 computer has been installed which has a two megabyte memory and the ability to handle up to 32 terminals (or up to 96 terminals with additional main memory). Existing programs are being converted; however, the two NOVA computers are being kept in operation during the change-over period.

F.35. Data Processing currently provides the following services with data entry mainly through cards:

Maize Program - Processing international trials data, production of field books and mailing labels, inventory control of the germplasm bank, and statistical analyses.

Wheat Program - Processing international trials data, production of field books, tags and packet labels, and statistical analyses.

Economics Program - Survey analyses.

Laboratories - Statistical analyses.

Publications - Mailing-list maintenance and control systems.

#### 4.4 Staffing and Equipment

F.36. Data Processing presently has a head of the unit, a secretary, a systems manager, two systems analyst/programmers on a regular basis, two systems analyst/programmers contracted to convert programs, two data processors, one supervisor of the data entry group, and three key-punch operators.

F.37. In addition to the basic VAX 11/780 system there are three disk systems, 12 video terminals and several key punches. The VAX 11/780 system has a FORTRAN compiler.

#### 4.5 Accomplishments

F.38. CIMMYT is to be commended for its efficiency and forethought in installing a well-designed computer system. In addition to providing the services listed in section 4.3 above, Data Processing has updated the programs for analyzing data from trials to filter out reporting errors.

#### 4.6 Future Plans

F.39. The following future plans were provided by the Data Processing Unit.

- (1) Computer programs that are currently inefficient and inflexible will be re-writtten.

- (2) Studies will be conducted before the end of 1982 to determine the appropriate locations for terminals, and on-line terminal entry of data will be instituted.
- (3) Data Processing, in conjunction with the other programs, will continue to encourage collaborative research projects to study the unique data base that has accumulated at CIMMYT. The computer programs developed in the collaborative project at Hohenheim University will be converted to operate on the VAX.
- (4) Programs developed for CIMMYT at IPO, Wageningen to analyze and interpret disease surveillance data will be converted for use on the VAX. This will allow data for the global disease surveillance project to be consolidated, analyzed and interpreted in Mexico.
- (5) Collaborative projects will be sought to assist the Data Processing Unit to provide improved data processing and statistical services.
- (6) New applications for the computer will be explored including automatic recording of data in the field and laboratory.
- (7) By mid-1983 it is planned that accounting services will have purchased software that will be installed on the VAX.

#### 4.7 Assessment and Recommendations

F.40. Data Processing has made important contributions to international testing and other programs of CIMMYT, and the future plans outlined in section 4.6 above are highly appropriate. However, in the past, CIMMYT has not made full use of available computer technology. This is difficult to understand since much of the activities of CIMMYT involve the management of information and data. The Panel recommends that the Data Processing Unit be given the strong support and leadership needed for it to accomplish its future plans.

F.41. The Panel recommends that CIMMYT consider developing a comprehensive system of data storage and retrieval that would enable staff to determine the pedigrees and characteristics of a wide range of genotypes, and search germplasm banks and working materials for genotypes with specific characteristics.



F.42. The Panel recommends that, funds permitting, the Data Processing Unit should be strengthened by recruiting one international staff member in the area of statistics/computer technology to provide the expertise needed to assist the staff of the Maize, Wheat and Economics Programs in the important task of obtaining more comprehensive and detailed analyses of the data from the international trials, and in designing experiments.

## 5. Publications

### 5.1 Background and Objectives

F.43. CIMMYT has a Communications Unit which forms part of the Center's Information Services. This group is directly responsible to the Deputy Director General for Research and indirectly to all directing staff. The objectives of the group as stated by CIMMYT are:

- (1) to support the information needs of CIMMYT's scientific and administrative staff.
- (2) to develop a system of timely reporting of scientific information to national collaborators and other members of the scientific community.
- (3) to develop brochures, visual aids and other materials to support CIMMYT training activities in Mexico and in the Regional Programs.

### 5.2 Organization and Procedures

F.44. The Communications Unit is organized in two sections--Publications and Audio-Visuals. The primary activity of the unit is preparation of publications for which the unit derives guidance from the Publications Committee made up of the directing staff under the chairmanship of the Deputy Director General for Research. This Committee is responsible for determining publication priorities, reviewing proposals for publications, and setting overall publications policy. Single copies of CIMMYT publications are distributed free of charge to scientists and research organizations throughout the world. CIMMYT's official language is English but half of the publications are also issued in Spanish and a lesser proportion in French.

### 5.3 Staffing and Facilities

F.45. The Communications Unit in CIMMYT comprises 14 staff members and is allocated 2.7% of the core budget. It is the smallest Communication Unit, in terms of staffing and resources, of the established IARCs. Senior staff comprise one supervisor and two science writers. A fourth position is not filled due to financial constraints. All typesetting is done at CIMMYT and printing is done by contracting with firms in Mexico. There are at present at least 20 approved titles pending publication. A video filming capacity was installed in 1978, and a new slide library system was installed in 1980 to improve storage and retrieval of slides.

### 5.4 Accomplishments

F.46. In spite of the small staff and budget, the Communications Unit has made good progress in both quantity and quality of CIMMYT publications. More support has been given to staff in preparing visual aids, and a computerized mailing system, which was installed in 1981, has enabled CIMMYT to reduce by 30 percent the number of copies of publications printed, and better identify groups of people to whom specific types of information should be sent. The Unit has also assisted the Center's management with substantial administrative writings, especially in producing reports, narratives and summary information sheets for special projects. The contribution of the Unit in preparation of training materials has been beneficial to the training programs, especially in dealing with linguistic problems.

### 5.5 Future Plans and Constraints

F.47. CIMMYT plans to develop more training materials using both printed brochures and audio-visual systems. Production of audio-visual materials is at present temporarily suspended due to shortage of staff and some technical difficulties. In anticipation of funding problems from the core budget, a grant proposal for special funding is being prepared to finance this expansion. The main constraints for publications, however, may be the small number of senior staff (science writers) and inadequate

participation by scientific staff. Projections over the next five years show that, in the best circumstances, the number of such staff may only increase from the present three international staff to four. The section has also suffered from rapid turnover in senior staff. This may be partially due to understaffing in relation to the amount of work that needs to be done, and difficulty in recruiting multilingual science writers.

#### 5.6 Assessment and Recommendations

F.48. The Communications Unit has made a considerable contribution to the operations of CIMMYT, especially in the last five years. There is, however, need to develop a clear publications policy, especially regarding the contributions of scientists themselves in terms of scientific writing and the development of training manuals. Short-term consultancies could also be used in special projects to supplement the permanent staff.

F.49. The 1976 quinquennial review recommended that the Information Services staff should play an innovative role on their own with respect to information output, and that they should also participate in training national research and production agronomy staff in techniques of communication. The group has responded well to the first objective and the Panel were shown an impressive collection of well prepared and beautifully illustrated pamphlets. The second objective has, however, proved difficult to achieve with the current number and turnover of senior staff.

F.50. The Panel recommends that the Communications Unit should be provided more opportunity to play an innovative role in assisting training and scientific staff to develop training materials and technical manuals of value to trainees, National Program staff and farmers.

## 6. Library Services

### 6.1 Organization and Functions

F.51. CIMMYT has a relatively small library which subscribes to 181 important journals, in scientific fields, and contains 3,500 general references and about 50,000 reprints. The facility is managed by the Librarian, and its operations are overseen by a Management Committee comprising the Deputy Director General for Research and one representative each from the Maize, Wheat and Economics Programs and the Communications Unit. The Committee is largely instrumental in determining budgets, and priorities in terms of new acquisitions. The Library produces and circulates to staff, current contents brochures monthly, highlighting new acquisitions and subject citation alert listings. This information is mailed regularly to CIMMYT staff located in regional programs. Such staff are also supplied, on request, with reprints of articles of interest in their work.

### 6.2 Accomplishments, Future Plans and Limitations

F.52. The CIMMYT Library has provided an adequate service to staff by establishing a good working relationship with other libraries in Mexico and elsewhere. Through this system, research staff are not seriously constrained by the small holdings in the Center Library and can obtain bibliographies and access to more comprehensive literature through loans and reprints. If funding is available, the Library plans to install a computer terminal to create and use bibliographic research databases. The facility may also enable the Library to link up with documentation centers outside the Center. Although the Library is not expected to expand much in coming years, the present space is already congested and additional space will become necessary in the near future. The Panel suggests that consideration be given to relocating the Library to provide more room for expansion, and to enhancing information services through the use of the computer, when funds are available.

## 7. Station Management

### 7.1 Background

F.53. The various experiment stations used by CIMMYT in Mexico were selected because they represent different developing country environments--highland to lowland tropics and humid to semiarid--for which CIMMYT is developing germplasm. These stations were mainly developed to their present condition during the period 1970 to 1976.

### 7.2 General Objectives

F.54. The following objectives were provided by the Station Management Unit.

- (1) Support crop improvement research activities through providing cultural operations and managing field labor for the breeding nurseries at all CIMMYT experiment stations.
- (2) Offer an in-service training program for experiment station personnel from collaborating National Programs.
- (3) Provide consultation services in experiment station development and management to collaborating National Programs.

### 7.3 Organization and Procedures

F.55. CIMMYT works primarily on five experiment stations in Mexico. Four of these stations are managed directly by CIMMYT. These include El Batán (which has 56 ha for cropping), Toluca (86 ha), Poza Rica (46 ha), and Tlaltizapan (32 ha). The major Wheat Program experiment station, CIANO, Ciudad Obregon, Sonora, is managed by INIA.

F.56. Two breeding cycles are carried out each year at Poza Rica and Tlaltizapan, and CIANO (until 1981). Toluca and El Batán are basically used for only one improvement cycle per year. Budget cutbacks have resulted in a reduction in the number of testing locations for the maize program. Since 1981, the use of the Toluca and CIANO stations for maize has been discontinued.

#### 7.4 Staffing, Facilities and Equipment

F.57. Station Management has a Head, an Assistant Head and a Training Officer. The facilities and equipment appear to be appropriate and in excellent condition.

#### 7.5 Accomplishments

F.58. The experiment stations and crops are maintained in excellent condition by the Station Management Unit, and additional cropping area (15 ha) has been developed at El Batan since 1976. The experiment station staff conduct two training courses per year on the principles of experiment station management. Each of the courses is 4½ months in duration and has 5 to 7 trainees. Members of the Panel can personally attest to the important contributions of the training course on experiment station management to the National Program staff of Ecuador. In addition, the experiment station staff have provided consulting services overseas on experiment station development.

#### 7.6 Future Plans and Constraints

F.59. The activities of the Station Management Unit were given a high priority classification under previously anticipated funding levels. Under serious funding shortfall scenarios, consideration will be given to eliminating the training program, severely reducing overseas consultation and reducing the number of approved international staff positions in this unit.

F.60. In the future, there may be constraints on experimentation due to the limited area for cropping, in relation to needs, at El Batan and Toluca.

#### 7.7 Assessment and Recommendations

F.61. The progress of the Maize and Wheat Programs of CIMMYT is highly dependent upon the condition of the CIMMYT experiment stations.

Presently, the management of these stations is excellent. The Panel recommends that the funding and staffing of the Station Management Unit be maintained at a level which enables it to continue to provide excellent services to the Maize and Wheat Programs.

F.62. The Panel commends the Station Management Unit for providing unique and important educational opportunities in experiment station management and development, and recommends that this should continue.

#### 8. Plant Quarantine

F.63. The first quinquennial review of CIMMYT pointed out the need for careful quarantine procedures when, as in the operation of CIMMYT, large quantities of seed are transferred among countries.

F.64. The Panel examined the procedures taken by CIMMYT when receiving and sending seed, and considers that CIMMYT takes all reasonable precautions and uses appropriate phytosanitary methods.

## CHAPTER G

COOPERATION WITH NATIONAL PROGRAMS AND OTHER CENTERS1. Introduction

G.1. CIMMYT has adopted the strategy of promoting improved production of maize and wheat nationally and internationally by making available to National Programs improved germplasm with wide adaptability to various ecological conditions. Advice is also provided on production technology which could be used to make optimum use of farm inputs. Training is also organized for national staff in both production and breeding methodology. In adopting this strategy, CIMMYT has recognized that the factors which determine crop productivity are to a large measure location specific and are by nature dynamic. The responsibility for actually improving production of these crops within a specific country resides with the national governments and agencies appointed by them to ensure that a reasonable proportion of available resources is directed to food production. Thus the only guarantee for sustained production is the development of local capability to improve continually germplasm through local selection and breeding and to improve agronomic practices through experimentation. It is, therefore, vital for CIMMYT to support national efforts by identifying the main production constraints affecting various regions, and to evaluate continuously throughout the world new germplasm which could be used in breeding better adapted varieties. In this process CIMMYT uses facilities at headquarters in Mexico and collaborates with various National Programs and Centers which may be better suited for various specialized investigations.

2. The Role and Functions of CIMMYT Regional Programs2.1 Rationale

G.2. The TAC stripe analysis of off-campus activities of the IARCs stated that in general it is not possible for a Center to carry out all of its research programs at any one location, whether this is on the



campus or not. This is true of CIMMYT which seeks to develop varieties and production technology for wheat, triticale, barley and maize - cereals which have wide geographical distribution in the world. The compelling need to promote regional cooperation among national institutions in developing countries, and the capacity of the few well-trained National Program scientists to extend training to other local scientists prompted CIMMYT as far back as 1973 to develop off-campus regional activities funded from the core budget. This was in fact an attempt by CIMMYT to extend its core program so as to benefit National Programs more effectively. This strategy was endorsed by the 1976 quinquennial review and subsequently by TAC.

## 2.2 Responsibilities of CIMMYT Staff in Regional Programs

G.3. The functions of CIMMYT Staff in Regional Programs are:

- (1) to promote closer interaction with National Programs especially in the cooperative effort in the world-wide testing and development of maize and wheat germplasm.
- (2) to identify technical constraints which may affect the use of improved germplasm in increasing food production and to assist whenever possible in developing agronomic and economic solutions to such problems through on-farm research and other means for using available technology at the national level.
- (3) to assist in definition of training requirements, selection of candidates for training, and the continued encouragement and technical support of national staff in maintaining crop improvement and production activities.

G.4. These functions call for a careful choice of regional staff and the Panel was informed that CIMMYT policy is to post only highly qualified persons to the regions. Such staff are, therefore, posted only after a period of service at headquarters where they develop adequate knowledge and experience of CIMMYT philosophy and objectives, as well as a thorough understanding of the major operating procedures.

## 2.3 Criteria in Establishment of Regional Programs

G.5. The main criteria used by CIMMYT in establishing Regional Programs are:

- (1) The importance of maize or wheat production and consumption in the region.
- (2) The existence and nature of national research capacities.
- (3) The specific types of production problems that a regional research focus can help to address.

G.6. Other factors such as similarity in production environments and problems, and the general agreement by the countries concerned to strengthen, through regional cooperation, the exchange of germplasm and scientific information among themselves are also taken into consideration. The choice of location for the operational bases of Regional Programs is, however, governed mainly by ease of communications, the availability of a strong National Program and its readiness to collaborate in regional activities, facilities for staff and their families, and the willingness of the national government concerned to host the program base. Efforts are also made wherever possible to utilize the physical facilities of another IARC which may be based in the region, as is the case with ILRAD in East Africa, IITA in West Africa, ICARDA in the Middle East, and CIAT in Latin America.

G.7. The number and coverage of Regional Programs established by CIMMYT at the time of the review, together with their staffing strength, are shown in Table G1. Figures G1 and G2 show the changes in the distribution of international staff and research funds, respectively, between National Programs, Regional Programs and headquarters in the period 1976-1982 plus projections for 1983. The funds for National Program projects, however, come from extra-core sources. CIMMYT's long-range plan calls for three Regional Programs in Latin America, three in Africa, and three in Asia. The minimum levels of staffing for effective programs, however, vary depending on the nature of production problems and the strength of National Programs. The Maize Program considers two staff members - one in crop improvement and the other in crop production

Table G1 Current CIMMYT Regional Programs

Regional Maize Programs in 1982

Region and operations base	No. of cooperating countries	Start of CIMMYT arrangements	CIMMYT staff assigned	Current donor/ Types of funds
Central America & Caribbean (Mexico)	13	1974	3	Switzerland
South and South East Asia	11	1976	2	UNDP/Rockefeller Foundation
Andean countries (CIAT, Colombia and Ecuador)	5	1976	3	Core Unrestricted
Mideast (Turkey)	9	1979	1	Core Unrestricted
East Africa	5	1982	1	OPEC/Core Restricted
West Africa (IITA, Nigeria)	13	1980	2	Core Restricted

Regional Wheat Programs in 1982

Disease Surveillance (Turkey)	22	1973	1*	Netherlands Core Restricted
Eastern and Southern Africa (Kenya)	17	1976	1*	Core Unrestricted
Andean countries (Ecuador)	5	1976	2	Core Unrestricted
Southern Cone (Chile)	5	1978	2	Japan/CIMMYT
North & West Africa & Iberian Peninsula (Portugal)	19	1980	1	Core Unrestricted
ICARDA (Syria)	11	1980	1	Core Unrestricted
South & Southeast Asia (Thailand)	12	1980	1	OPEC/Core Restricted

(\*) A Dutch associate scientist is also assigned to these regions.

Table G1 Current CIMMYT Regional Programs (Continued)

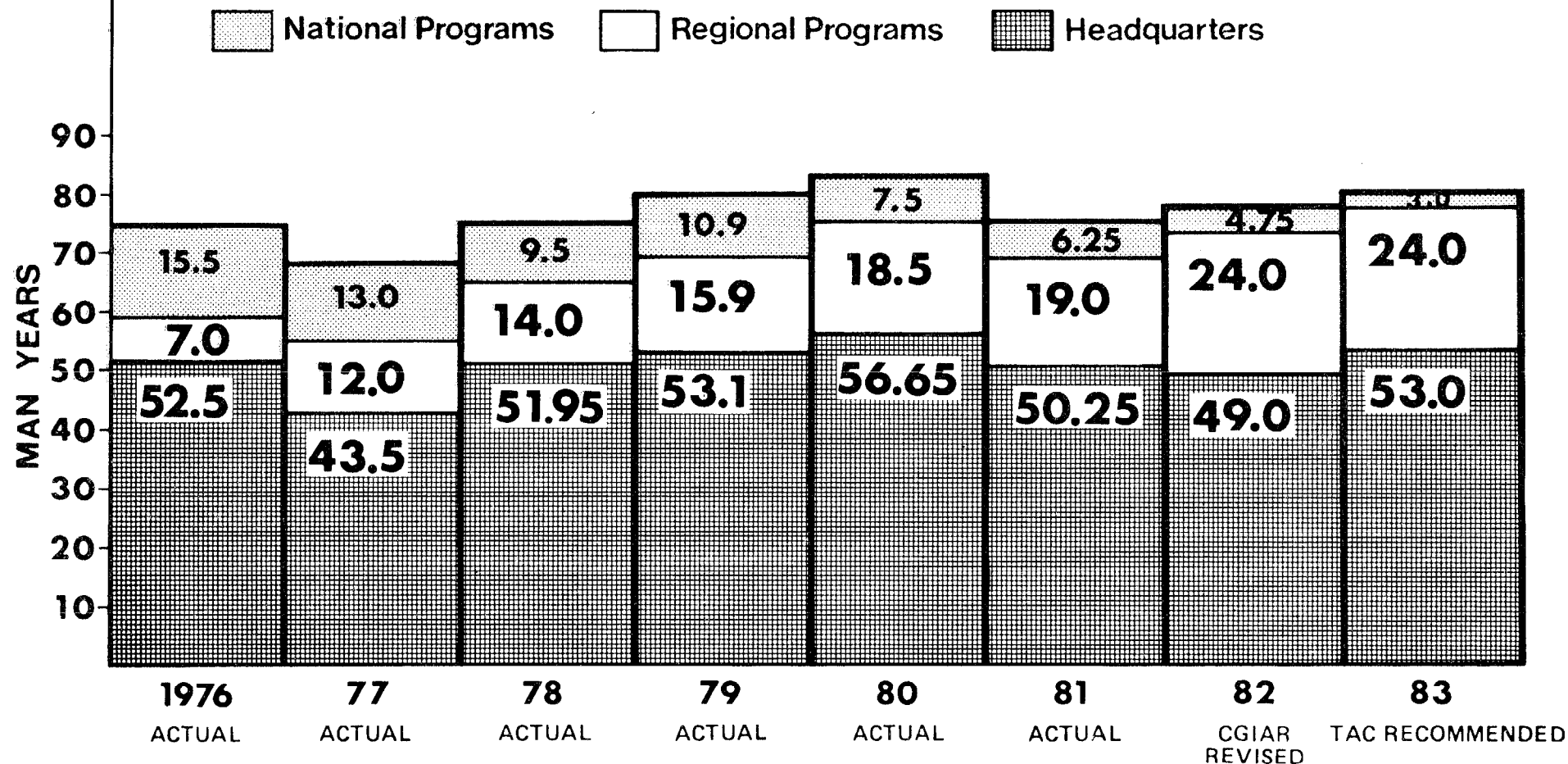
Regional Economics Programs in 1982

Region	No. of countries	Start of activity	Staff assigned	Current donor
Eastern Africa	4	1976	1	UNDP
South & South-East Asia	5	1979	1	Core Unrestricted
Andean	4	1977**	1	Core Unrestricted
Central America & Caribbean	5	1978	1	Switzerland

(\*\*) Completed 1982.

Figure G1

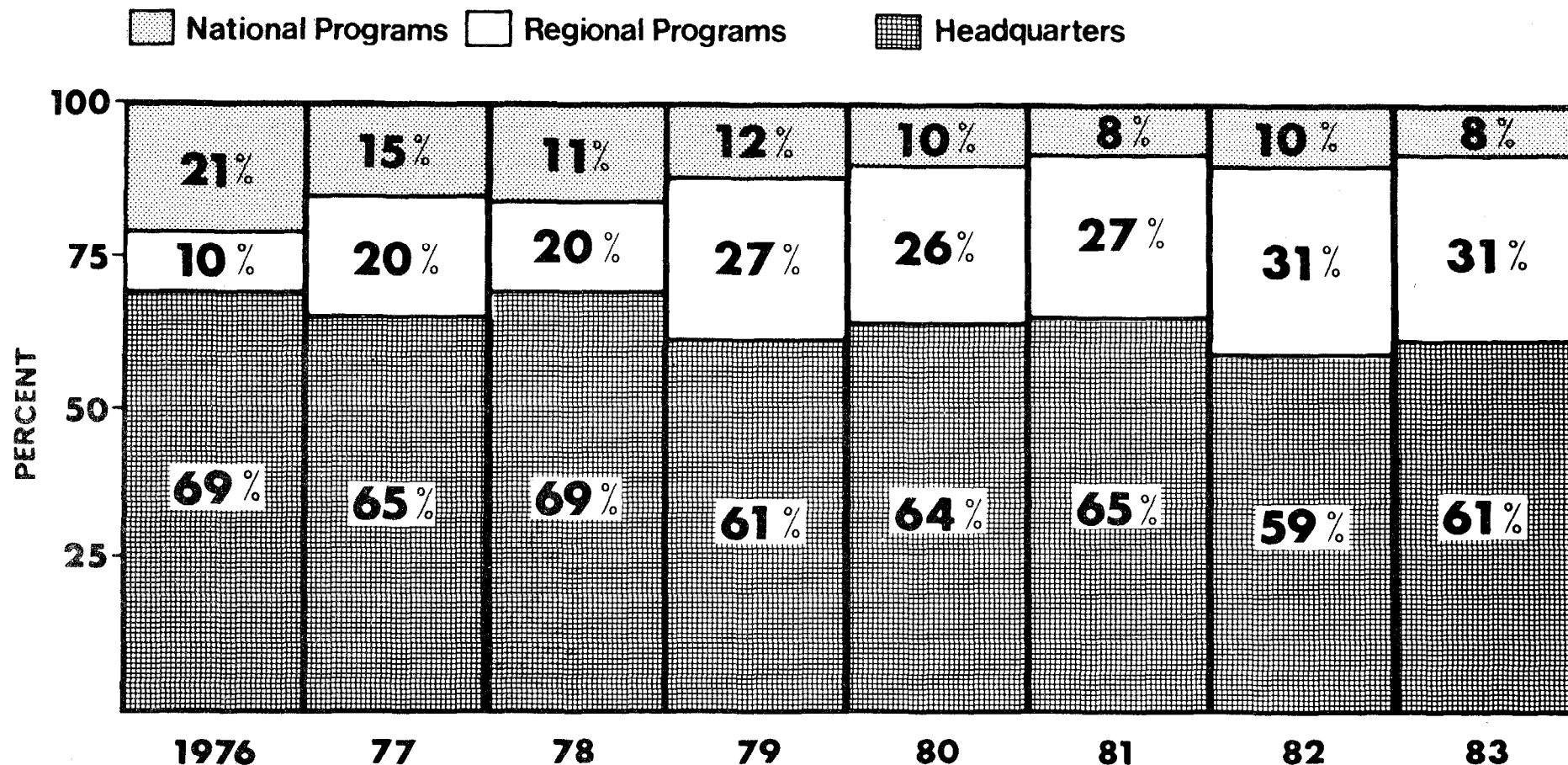
# DISTRIBUTION OF INTERNATIONAL STAFF



SOURCE: CIMMYT BUDGET DOCUMENTS

Figure G2

# DISTRIBUTION OF RESEARCH FUNDS



155

SOURCE: CIMMYT BUDGET DOCUMENTS

- as the minimum desired level. The Wheat Program, with more crop species and disease problems to contend with, considers three staff members - breeder/pathologist and agronomist (and an economist) - to be the minimum desirable. The Economics Program generally assigns only one senior economist to each of its Regional Programs.

#### 2.4 CIMMYT's Achievements and Constraints in Regional Programs

G.8. Detailed discussion of CIMMYT's achievements in the Regional Programs is contained in the chapters on wheat, maize and economics. It suffices here to state that, in general, these regional activities have proved effective in extending CIMMYT's influence and expertise in the development of National Programs in both research and production. Examples can be cited where maize production has developed well in Ecuador, in Guatemala, and in East and Central Africa where the economics input in agricultural research has gained wide acceptance and is being implemented in Kenya, Zambia and Zimbabwe.

G.9. The main constraints in the Regional Programs have been the difficulties in posting adequate staff due to financial constraints and the difficulties experienced by National Programs in retaining trained personnel, operational capability in research, and provision of inputs in the crop production systems. In such cases, CIMMYT's Regional Program staff have not been able to develop as adequate a contact with national staff as they would like and hence, have been somewhat constrained in stimulating national research or production activities.

### 3. The Role and Functions of CIMMYT in National Programs

G.10. CIMMYT has had many bilateral agreements with National Programs particularly in Asia (India, Pakistan, Bangladesh) and Africa (Algeria, Egypt, Morocco, Tanzania, Ghana, Zaire) and in Guatemala. CIMMYT's objective in such programs has been to focus special attention on specific research problems. These programs, therefore, take the form of Special Projects funded from extra-core sources and usually involve the assignment of CIMMYT staff to work within National Programs for fixed-term periods.

### 3.1 Responsibilities of CIMMYT Staff in National Programs

G.11. The bilateral agreements between the donor and the country concerned specify the input to be provided by the donor (some through CIMMYT), including the qualifications of the scientists to be posted to the Program. However, once CIMMYT personnel are posted to the National Programs, they become administratively responsible to the National Program but are free to draw on appropriate technical and other logistic support from CIMMYT headquarters. The CIMMYT scientist working in a project with a National Program may be assigned the role of Project Coordinator in which case he/she becomes responsible, with the help of a local counterpart, for organization and administration of both technical assistance and local resources, and for overall supervision of activities under the project. Manpower development is an important role and CIMMYT staff are expected to ensure appropriate training - both in-service and at CIMMYT or elsewhere - for local personnel who would eventually man the Program. The relevant Program Directors in CIMMYT, therefore, become involved in these projects, and various administrative services at headquarters are also involved in providing logistic services to the project.

### 3.2 Criteria Used in Establishing Bilateral Projects with National Programs

G.12. Several criteria are used in deciding to place CIMMYT staff within a collaborating National Program. In most cases, such agencies are in their formative stages of institutional development or are in the process of rebuilding their capacities after experiencing decline. Some of the main criteria for CIMMYT participation are:

- (1) That the particular country government be prepared to make a strong commitment to strengthen its own research capacities.
- (2) That there are unique research challenges and lessons to be learned in a particular country that would be of benefit to CIMMYT in fulfilling its mandate.

G.13. CIMMYT has, however, found involvement in such programs too demanding in terms of logistic support in spite of a 15 percent overhead



charge which is used to offset expenditure on support services. A number of bilateral projects with National Programs have therefore been phased out in the last few years in favor of Regional Programs which CIMMYT considers more cost-effective in reaching the large number of developing countries requiring CIMMYT support. Table G2 shows the bilateral National Programs in which CIMMYT is currently active.

Table G2. Current CIMMYT Activities in Bilateral Projects with National Programs

Country	Start of CIMMYT activity	CIMMYT Staff	Donor
Pakistan *	1970	1	USAID
Tanzania	1973	1	USAID/IITA
Ghana	1979	1	CIDA (Canada)
Bangladesh	1982	1	CIDA (Canada)

(\*) Initiated by Ford Foundation/USAID in 1965.

### 3.3 CIMMYT's Achievements in Bilateral Projects with National Programs

G.14. As a production-oriented Center, CIMMYT has had substantial success where effort has been concentrated in a collaborative project with a National Program. Examples of this can be seen in the case of India where wheat production has increased to a level of self-sufficiency in about ten years, and Pakistan and Bangladesh where wheat production has increased significantly. The Panel visited a number of such projects and the Ghana project is described in some detail as an example of CIMMYT's contribution in revitalization of national capacity through special projects.

### 3.4 The Ghana National Maize Improvement Program

G.15. The National Maize Improvement Program in Ghana now based at the Crops Research Institute, Kumasi, has been in existence since around 1950 and has been quite successful in selection and development of composites adapted to various ecological zones. The important Ghanaian varieties - La Posta, Composite 4, Composite W, and Giant Composite - have resulted from this program. Intensive trials and selections are continuing to improve yield and other characteristics such as husk cover and resistance to lodging. The contribution of CIMMYT maize germplasm to the National Program has therefore been substantial over the years, and La Posta appears to have established itself as a major source of well-adapted varieties in the future for some countries in the West African region.

G.16. In spite of earlier gains it became evident that the National Program could hardly be sustained due to lack of staff and that maize production was not responding as expected.

G.17. The Ghana Grains and Legume Development Project which is a bilateral agreement between CIDA and Ghana was, therefore, formulated in 1979 with the following objectives for maize:

- (1) increasing maize yields and yield stability through breeding of varieties adapted to the various ecological zones.
- (2) development of appropriate agronomic practices and technology through on-farm research and the promotion of extension of these practices to the small-scale farmer.
- (3) the use of farmer surveys and on-farm trials to generate the necessary information for formulation of national agricultural production policies.

G.18. The Crops Research Institute is the executing agent for Ghana but the Grains and Legume Development Board and the Ministry of Agriculture are involved in on-farm trials and extension. In this Project, CIDA contracted CIMMYT as executing agent for the project and CIMMYT has posted a staff member (agronomist) to Ghana as coordinator of the project. Over-

all control of the project is, however, vested in a Management Committee which includes the University, Seed Company, CIMMYT, IITA and CIDA. The first phase of four years is due to end in 1983 and a second phase is under consideration by CIDA.

G.19. The success of the first phase of the Ghana Project is impressive. Through the project it has been possible to regenerate enthusiasm and cooperation between the main government agencies responsible for improvement in food production. As the executing agent on behalf of CIDA, CIMMYT has provided virtually all logistic support for the Project - and perhaps more than its normal share - in view of the difficult economic situation in the country. The CIMMYT Project Coordinator has played a key role in ensuring timely availability of inputs and the necessary transport for local staff to supervise field trials at research stations and on farmers' fields. While the variety trials continue to produce improved lines, the agronomy trials have demonstrated the vital need for fertilizers in the impoverished soils, the possible combined use of herbicides and hand cultivation to control weeds, and technology for improving crop stand through use of high quality dressed seed and deeper sowing.

G.20. Nine local staff have also benefitted from training organized by CIMMYT under the Project, and those who have completed training have developed a very high level of enthusiasm, competence and dedication in all activities of the Project. The local staff emphasized to the visiting Panel members that the training provided by CIMMYT had given them confidence in handling the complicated maize improvement trials and that this kind of training should be extended to many more staff. The visiting Panel members were also informed that the Director of CIMMYT's Maize Program has taken keen personal interest in the Project. Strong backstop support has also been provided when needed by the CIMMYT Economics Program at El Batan.

#### 4. Collaboration with Other Centers

G.21. CIMMYT has recognized the need for cooperation with other Centers in the CGIAR family. The Center cooperates with IITA on maize improve-

ment in Tropical Africa and participates in workshops, and is hosted by CIAT in its work on maize improvement in the Andean Region. Previous cooperative programs between ICARDA and CIMMYT involved bread wheat, durum wheat, triticale and barley. ICARDA was doing breeding work in all crops, running its own nurseries in the region and exchanging material with CIMMYT, plus convening joint planning meetings. As of 1982, ICARDA has given bread wheat and triticale back to CIMMYT, retaining durum wheat and barley. CIMMYT has made its headquarters facilities available to ICRISAT for sorghum work. CIMMYT also cooperates with IBPGR in management of wheat and maize germplasm resources, and with IFPRI on the position of its mandated crops in world production, consumption and trade, and conducts joint surveys with CIP. A new relationship is being developed with IRRI to develop rice and wheat varieties that can be used in rice-wheat rotations in Asia, and assistance is being provided to ISNAR in development of management seminars for policy makers. ILRAD provides office space for CIMMYT staff located in Nairobi.

G.22. Most of the relationships with other IARCs are covered by memoranda of agreements or other such written instruments spelling out the scope of activities and responsibilities of the parties involved. Some collaboration is often carried out under more informal agreements. The Panel commends CIMMYT for the level of cooperation achieved to-date and encourages the Center to continue to seek meaningful and beneficial relationships with other IARCs.

## 5. Assessment and Recommendations

### 5.1 Criteria in Establishment of Regional Programs

G.23. While the overall criteria specified by CIMMYT for establishment of Regional Programs coincide with the recommendations of TAC, it was not obvious to the Panel how these criteria had been used in establishing the current Regional Programs. The Panel gained the impression that the choice of regions was influenced partly by past CIMMYT activities in bilateral projects with National Programs and the desire to maintain these contacts. Geo-political groupings used by FAO, UNDP, World Bank,

etc. also play a role in the delineation of regions. The Panel considers, however, that the question of similarity of production environment should be taken more seriously through an analysis of ecological factors. The Panel therefore recommends that CIMMYT should take steps to utilize the available agroclimatic information and all other information considered important at the local level in setting up Regional Programs.

## 5.2 The Image and Coordination of CIMMYT Activities in Regional Programs

G.24. The current organization of CIMMYT into three distinct and to some extent independent programs, namely wheat, maize and economics, seems to be perpetuated in Regional Programs as well. While the emphasis in a particular region could well be maize, wheat or economics, the Panel considers that Regional activities should be seen first and foremost as "CIMMYT Programs" and mechanisms should be developed to ensure complementarity of personnel in Regional activities.

## 5.3 The Role and Future of Current Regional Programs

### 5.3.1 Programs in Eastern and Southern Africa (Wheat, Economics)

G.25. This Wheat Regional Program was started as a core activity of CIMMYT in 1975 with the objective of assisting the National Programs of North Africa and the Near East by providing a summer nursery in the Njoro area of Kenya which is a 'hot spot' for cereal rusts. CIMMYT is also able to screen both wheat and barley for resistance to rusts at this site. A CIMMYT breeder/pathologist located at Njoro enabled the establishment of liaison among the National Programs of Ethiopia, Kenya, Somalia, Zambia, Tanzania, Malagasy and other countries in the region. This program has been quite successful and several varieties of bread wheat derived from the trials have been released in Burundi, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mozambique, Rwanda, Tanzania, Zambia and Zimbabwe. Kenya, and the East African region as a whole, have also benefited (through this Program) from new lines developed in the Near East. A number of triticale lines have also been incorporated in these trials

and have demonstrated an average yield advantage as much as 20 percent over the best bread wheats in the region.

G.26. The Economics Program has concentrated on the identification of production constraints and the development and institutionalization of on-farm research. The Panel noted that this Program has greatly assisted in the training of agricultural economists and the integration of this discipline in agricultural research. There are plans to post a maize agronomist to the region.

G.27. The Panel recommends that the Regional Program in East and Southern Africa be continued and endorses the plan of the Maize Program to stage an agronomist in the Region.

#### 5.3.2 Programs in the Andean Region (Economics, Maize, Wheat)

G.28. The Andean Program covers Bolivia, Colombia, Ecuador, Peru and Venezuela. The wheat component of the Program comprises screening nurseries for diseases and agronomic attributes. It includes standard CIMMYT nurseries containing superior new bread wheat lines from CIMMYT, spring wheat varieties from both CIMMYT and National Programs, and Septoria observation nurseries.

G.29. The Panel observed that a number of varieties of wheat have already been released from this Program which has also distributed material for use in breeding in other parts of the world. More progress has, however, been made on wheat than on barley due to greater effort and staff stability in wheat activities. The Panel suggests that this imbalance should be corrected since barley is grown on more than 400,000 ha of land mainly as a food crop compared to 250,000 ha for wheat in the region. Triticale also offers special advantages in parts of the region which are marginal for wheat due to soils and climatic conditions.

G.30. The maize component of the Program was started in 1974. A lowland variety (INIAP 526) and a highland variety (INIAP 101) have already been developed from CIMMYT material and have been released, partially as a result of on-farm research activities stimulated by a CIMMYT economist.

G.31. The Panel recommends that activities in the Andean Region be continued, but that the wheat and barley components of the Program be reassessed relative to their production potentials. The highlands maize program should continue to receive high priority.

#### 5.3.3 Programs in South and South East Asia (Wheat, Maize, Economics)

G.32. The wheat component of the Program, which is based in Thailand, is concerned mainly with agronomy and plant diseases, especially leaf and yellow rust. The National Programs in India, Pakistan and Bangladesh are well developed and the role of CIMMYT in these countries is mainly catalytic. The main focus of the maize component of the Program is on downy mildew and is carried out through a shuttle-breeding program between the region and Mexico. This work has reached the stage of Experimental Variety Trials. A CIMMYT economist is also located in the region and works in collaboration with the maize and wheat personnel. The Panel recognizes the excellent progress that has been made in food production and training in South East Asia and recommends that CIMMYT reassess the type and extent of activity that is needed in the region. This observation results from the recognition of the growth and strengthening which has occurred in the National Programs in the countries of the region.

#### 5.3.4 Programs in the Central America and Caribbean Region (Maize, Economics)

G.33. This was the first Regional Maize Program and was started in 1954 with 13 cooperating countries.<sup>1/</sup> The main emphasis is on breeding and selection for corn stunt and ear rot. Stunt-resistant experimental varieties have been identified and were distributed in Experimental Variety Trials in 1981. A good impact has been achieved, especially in Guatemala and the Panel recommends that CIMMYT activities in this region continue to receive high priority.

<sup>1/</sup> This program was initiated as a regional activity in Central America by the Rockefeller Foundation in 1954.

#### 5.3.5 Southern Cone Regional Wheat Program

G.34. This Program which covers five Southern Cone countries of South America has two CIMMYT wheat scientists - a breeder and an agronomist. The Project is based at the National Agricultural Research Institute (INIA) in Chile and cooperates with IICA. The review team was informed that in this region the main problems in production were not related to the suitability of varieties, but were agronomic and socio-economic. Special emphasis is therefore being devoted to soil fertility problems, especially aluminum toxicity and phosphorus fixation. The Panel considers, however, that the countries comprising this region are generally well advanced and recommends that CIMMYT activities in the region be accorded lower priority.

#### 5.3.6 North and West African Wheat Program

G.35. This program started in 1980 and covers West Africa, North Africa and the Iberian peninsula. The Program is based in Portugal where a CIMMYT breeder is located. A pathologist is also due to be posted to the region. Close collaboration occurs with ICARDA and the main activity is breeding for resistance to Septoria and rusts. Weed control and moisture conservation are important, hence the need for input from agronomists. The Panel considers that the future of CIMMYT activities in this region be reconsidered in the light of the mandate of ICARDA. Further, the Panel considers the grouping of countries in this region to be anomalous, since North African and West African countries have little in common.

#### 5.3.7 Mideast Regional Program - Relationship with ICARDA

G.36. ICARDA, as one of the IARCs, has regional responsibilities for improvement of crop productivity in arid lands. All crops grown or those having potential value are to be investigated under the mandate of ICARDA. CIMMYT has interpreted its mandate to include the development of germplasm for wheat and barley anywhere those crops are or may be grown. Historically, CIMMYT has not had substantial resources assigned



to breeding programs specifically for (1) rainfed (water-limited) sites where spring habit varieties are suitable, or (2) areas (primarily rainfed) requiring cold-tolerant varieties. In both cases four crops are involved - barley, bread and durum wheats, and triticale. It is the Panel's judgement that, for CIMMYT to serve both of these needs, increased resources in terms of senior staff must be assigned and field sites outside of Mexico must be used. Further, it is agreed by the Panel that areas included are of such magnitude and importance that IARC attention is warranted at a high priority level. The majority of the areas requiring cold-tolerant wheats falls within the ICARDA region, and that region also includes vast rainfed areas where spring wheats are suitable, but it is by no means the only area. It is an important programmatic question for the IARC system to develop an efficient management plan for serving the germplasm needs as defined above. Various models were examined by the Panel and two of them are presented below.

G.37. In the first model ICARDA would have global responsibility for barley and winter wheat (bread and durum) germplasm development and distribution and CIMMYT would have similar responsibility for triticale and spring wheats (both bread and durum) germplasm development and distribution.

G.38. The second model would assign management responsibilities for all germplasm development and distribution to CIMMYT. CIMMYT would then second scientific staff to ICARDA as needed for all germplasm development activities that could be most efficiently managed from that Center. This provides for a complete coordination of effort in germplasm management. ICARDA would have responsibility for crop management research for rainfed and irrigated production within its geographic region.

G.39. The Panel favors the second model and recommends that CIMMYT and ICARDA enter negotiations to make programmatic and administrative adjustments as needed to assign germplasm development, including breeding, to CIMMYT and crop husbandry with related farming systems activities to ICARDA.

#### 5.3.8 West African Maize Regional Programs - Relationship with IITA

G.40. In the Assessment and Recommendations for the Maize Program (Chapter D, section 7) the Panel recommended that the value of a completely integrated network for maize breeding, directed by CIMMYT, be seriously considered when the future and the relationships of the Maize Programs at CIMMYT and IITA are examined by TAC and other organizations.

G.41. However, assessment of the total relationship between the West African Regional Program and IITA requires consideration of the other activities of Regional Programs. Farming systems research, agronomy, economics, pathology and entomology are usually site-specific; and IITA has considerable strength in these fields. Consequently, the Panel recommends that research and training in West Africa, on aspects of farming systems, agronomy, economics, pathology, and entomology that relate to assisting National Programs in the development of maize production technology, should be the responsibility of IITA. These programs and activities of IITA should be closely coordinated with the Maize Breeding Programs of CIMMYT, especially with respect to projects on breeding for resistance to diseases and pests.

#### 5.4 The Role and Future of CIMMYT in Bilateral Projects with National Programs

G.42. Given suitable conditions, CIMMYT activities in bilateral projects with National Programs have proved very successful in increasing production. However, CIMMYT does not have sufficient resources to support the many National Programs in this manner. Expansion of such activities would also tend to detract CIMMYT from the more important long-term strategy of developing a sound base program at headquarters. However, there may be situations in which CIMMYT can provide back-up support or advisory services in maize and wheat without long-term posting of staff. The Panel endorses the actions and plans of CIMMYT regarding its involvement in bilateral projects with National Programs where necessary and appropriate to accomplish specific research objectives.

### 5.5 The Role of CIMMYT Personnel in Regional Programs

G.43. The role of CIMMYT personnel in Regional Programs will depend on the level of development of National Programs in the region, and will therefore vary from country to country. The Panel therefore endorses the CIMMYT policy that Regional Programs should be manned by strong and well-qualified staff and should be part of the core unrestricted budget of the Center in order to build up and retain a cadre of such staff. The Panel also noted that Regional Programs impose a heavy travel schedule on the Directing Staff and suggests that suitable arrangements be made to reduce this activity.

### 5.6 The Role of Regional Programs in Determining Research Priorities and Strategies

G.44. The participation of recipient countries in the development of priorities and research strategies at CIMMYT is of vital importance in National Program development and transfer of technology in order to increase crop production. The Panel considers that the presence of CIMMYT personnel in the wide network of Regional Programs provides a valuable opportunity in this respect and recommends that CIMMYT develop appropriate and effective consultative mechanisms in order to facilitate inputs from cooperating National Programs into the determination of priorities and research strategies at CIMMYT.

## CHAPTER H

OVERALL ASSESSMENT OF ACHIEVEMENTS,  
IMPACT AND CONSTRAINTS1. Review of the Recommendations of the First Quinquennial Review and  
Their Impact on CIMMYT's Program

H.1. In line with its terms of reference, the Panel inquired about the follow-up action taken by CIMMYT in response to the recommendations of the first quinquennial review. CIMMYT presented an overall review of the implementation of the recommendations of this 1976 review

Panel. When examining the CIMMYT programs in more detail, the impact of the first quinquennial review was also further investigated.

H.2. The Panel noted that the first review was carried out with terms of reference which were somewhat more narrow than those given for this second review. The first review concentrated mostly on the assessment of the scientific quality of the programs and was carried out in the context of the overall development of the CGIAR system which at that time did not face significant financial constraints. As a result, the recommendations of the first review tended to encourage the further expansion of CIMMYT's activities, and its regional programs in particular. In fact, however, the implementation of several recommendations of the first review was somewhat limited by financial constraints during the last three years.

H.3. Many recommendations of the first review were a strong endorsement of CIMMYT's strategies and programs and supported their continuation. In this regard, it can be said that the recommendations of the first review have been closely followed as there was no major departure from the directions approved by the first review for both the Wheat and the Maize Programs. Moreover, as recommended by the first review, CIMMYT recently cooperated in a general analysis of its wheat trials in order to evaluate the validity of its approach to wheat breeding (see Chapter C, sections 5 and 8.4).

H.4. The first review Panel recommended that CIMMYT maintain an active program in durum wheat and barley while seeking appropriate cooperative arrangements with ICARDA. The ICARDA programs had not really started at that stage and it was difficult for the first review Panel to make precise recommendations. As indicated in Chapter G, CIMMYT and ICARDA have been consulting each other as their respective programs developed. These consultations will need to be further pursued, in particular as regards durum wheat and barley (see Chapter G, section 4).

H.5. Another recommendation of the first review was that CIMMYT's work on triticales be included in its unrestricted core program so as to give it proper recognition and financial support. This was done in 1977 and, as recommended, a cytologist was appointed to monitor the breeding material developed under the triticales program.<sup>1/</sup> The development of a triticales germplasm bank at CIMMYT was also achieved as recommended. The core contributions to this program had to be subsequently reduced, however, as a result of the overall budgetary stringency.

H.6. In response to a recommendation for a strengthening of CIMMYT's activities and linkages in several basic research disciplines, recently the Center has increased its collaborative research arrangements with advanced research institutions both in developed and developing countries (see Chapter F, section 2.2). Although there have been some ups and downs in some disciplines, physiology in particular, significant developments took place recently in wide crosses, cytology and disease surveillance.

H.7. While the first Panel recommended that "production research should continue to concentrate (headquarters activities) on breeding research" because of the location specificity of other activities, CIMMYT's experience during these last years has indicated that agronomy and on-farm research are essential complements to ensuring the impact of its breeding programs. The validity of such development is discussed in the relevant chapters on the Wheat, Maize and Economics Programs.

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<sup>1/</sup> The Panel, however, noted that the cytologist's main work was directed to wide crosses rather than triticales.

H.8. During recent years, however, the training and communication programs of CIMMYT have been somewhat constrained by lack of funds and several of the recommendations of the first review Panel regarding training were not fully implemented.

H.9. Another development which was recommended by the first quinquennial review was that of the regional programs as part of the core activities of CIMMYT. The long-term plans of CIMMYT are still far from being fully implemented in this regard. However, there has been a significant increase of the regional programs during the quinquennium, not only for liaison and support activities but also, as indicated in Chapter C, section 3.6, Chapter D section 3.4 and in Chapter G, section 5, for different forms of decentralized research<sup>1/</sup>.

H.10. The role of the Economics Program as set out by the first quinquennial review (namely adoption studies, support to the crop programs, particularly in training, and contribution to priority setting in crop research) was in the main fulfilled and also broadened to include on-farm research, as indicated in Chapter E.

H.11. As to the development of additional facilities for germplasm conservation, significant acquisitions were made, but the present Panel recognizes the need to make further progress. Similar developments and further needs are recognized by the Panel as regards data processing.

H.12. On the whole, therefore, it can be said that most of the recommendations of the first review Panel have been followed. In some cases (economics, regional programs) the development of CIMMYT activities

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<sup>1/</sup> It should be noted that the supplement added to the report of the first quinquennial review after the visits to Tunisia and Egypt recommended the establishment of regional services to National Programs rather than regional programs. This difference apart, the criteria of CIMMYT for the establishment of regional programs generally follow those recommended in the supplement to the first quinquennial review report. Similarly the criteria for CIMMYT's involvement in national projects are also in line with those suggested by the first review Panel.

perhaps went beyond what the first review could anticipate as regards their scope and size. In one case (agronomy), the directions taken by CIMMYT appear to be at variance with the first review's recommendations. These developments are described in the chapters C, D, E and G above.

H.13. The previous Panel also made specific recommendations that were apparently not significantly addressed during the succeeding five years. Some examples include the following: (i) identification of disease resistance genes to be used in pyramiding resistances in bread and durum wheat breeding; (ii) further development and application of methodology for breeding varieties for water-limited environments; (iii) verification that daylength neutrality is a desirable characteristic for the Mediterranean region; (iv) a socio-economic study of the potential use of hulless barleys in targeted developing countries.

H.14. As to other recommendations and suggestions of the first review, the differences with the present policies and directions are more a matter of degree and nuance than of substance. A few, however, deserve further consideration: in particular, as regards the balance and spread of training activities; the role of post-doctoral fellows, professional development of scientific staff and opportunities for maintaining contacts with the scientific community (sabbatical leaves, publications, etc.); and CIMMYT's role in maize germplasm conservation. The relevant observations and recommendations of the Panel on these points are given in preceding Chapters.

## 2. Assessment of CIMMYT's Achievements and Impact during the Last Quinquennium

### 2.1. Preliminary Remarks

H. 15. As the cooperation of CIMMYT with National Programs expanded further during the last six years, it is increasingly difficult to identify and assess the share of CIMMYT in the output of the national research programs and their impact on production increases, both in their successes and failures. Moreover, as the process of technology genera-

tion, transfer and adoption is of a continuing nature, assessment made at a certain date for a definite period of time is necessarily arbitrary. The Panel attempted to evaluate CIMMYT's accomplishments in terms of the main functional tasks which the Center has set for itself in its mandate and overall strategy in cooperation with National Programs, namely: (i) the improvement of wheat and maize production; (ii) the development and distribution of superior germplasm, (iii) the strengthening of national maize and wheat programs through training and other means; (iv) the development of improved techniques and procedures in research and crop management; and, (v) the creation and dissemination of new knowledge. While CIMMYT usually presents the above list of targets by order of importance, these will be dealt with here in a different sequence for assessment purposes, following the process of technology generation with the related activities of methodology development and techniques, generation of knowledge, transfer and adoption.

## 2.2. The Development and Distribution of Superior Germplasm

### 2.2.1. Wheat

H.16. During the last quinquennium the production of high-performing, disease-resistant bread wheat varieties originating from CIMMYT material occurred at about the same rate as in the previous quinquennium. The release of durum wheat, barley and triticale varieties which originated from CIMMYT material increased. Thus, the breeding programs have sustained their high degree of effectiveness and continued to involve cooperators in more than 100 countries in both the developing and the developed world. Most of the germplasm improvement achieved by CIMMYT during this period has been based on a fuller exploitation of the sources of improvement already identified, or found in the germplasm collections of CIMMYT (mainly the semi-dwarf material and the crosses of winter and spring wheats). Some notable acquisitions in the new germplasm used by CIMMYT during these five years are sources of resistance to soil aluminium toxicity, scab and Helminthosporium, and earliness, and in particular material originating from China. Nevertheless, CIMMYT does not look at itself as the major repository for



bread wheat germplasm and only broadens its working collections with material which it considers as potentially useful for its improvement programs. Old land races and wild relatives of wheat which have been collected through the support of IBPGR are not used by CIMMYT as the Center looks for more promising and effective sources for rapid improvements. This approach appears to be valid at this stage since considerable progress has been made during the last six years in using CIMMYT's working collections for further advances both in raising the yield potential and resistance to a wider range of diseases. While it will take some more years before the wide-cross program may significantly contribute to germplasm development, more conventional methods of gene transfer between bread and durum wheats and from triticale and rye have produced lines with very promising traits for further improvement of the yield potential, resistance to disease prevalent in sub-tropical humid areas and tolerance to aluminum.

H.17. The main achievements in bread wheat during the last six years come from the spring and winter crossing program both in terms of increased yield potential and disease resistance. Considerable progress has been made also in introducing tolerance to aluminum in high yielding lines.

H.18. High and, so far, stable resistance to stem rust and to a lesser extent stripe rust has been developed for most production areas. Major progress was made in developing resistance to Septoria while similar efforts are under way for scab, Helminthosporium and leaf rust; progress with these appears to be more difficult to achieve at this stage, however.

H.19. Finally, the development of early maturing material with good disease resistance has opened the way to new developments in arid and highland areas with short growing seasons and in others where it made multiple cropping possible (e.g., with rice in Asia).

H.20. The major advances by CIMMYT in durum wheats was in raising their yield potential, which is now comparable to the best bread wheats, and in ensuring the maintenance of acceptable quality. Progress was also

made in developing earliness in durum lines as a means of escaping drought stresses, and in increasing cold tolerance and disease resistance.

H.21. Very important advances have been achieved during the last quinquennium in raising the yield potential of triticales to levels comparable to wheat. Problems of lodging and inferior grain quality have been largely overcome. Adaptation of triticales to difficult environments has been confirmed. Further efforts will be necessary to obtain earlier maturity and maintain the good resistance of triticales to diseases which may develop as planting of the crop expands in different environments.

H.22. The barley program, which had made a modest start when the first quinquennial review was held, has now developed much further and shows considerable promise in higher yield potential of both hulled and hullless barley, earliness (for arid areas or high altitude areas), lodging resistance and with some gains in total protein content and quality.

H.23. The distribution of superior germplasm to National Programs through the international nurseries continued to expand in terms of number of nurseries, of amount of material requested, and of individual cooperators and countries involved (see Chapter C, section 8). The operations of international testing nurseries have been improved by new facilities and by the support given by the regional staff in enhancing the quality of the trials in the field. Beside the increase in the scale of germplasm distribution, several trends were observed during the last six years: the growing interest of collaborators for crossing blocks, segregating materials and screening nurseries as inputs in their own breeding programs, and the growing number of varieties released by National Programs based on CIMMYT yield nurseries not only in bread wheat but also more recently in durum wheat, barley and triticales.

#### 2.2.2. Maize

H.24. The major achievements in the development of superior germplasm include: the further increase of the number of accessions in the maize

germplasm bank from 12,000 to 14,000; the broadening and further diversification of the gene pools; the further development and improvement of populations, including several with high lysine content and normal grain type; steady progress in reducing plant height while increasing yield potential and resistance to disease and insects <sup>1/</sup>; and early maturity.

H.25. The germplasm bank is now close to reaching its full capacity (15,000 accessions). It seems that CIMMYT will not feel constrained by the capacity of its germplasm bank since its main interest is not in the germplasm contained in the bank, but in that of the gene pools which constitute its working collection. The germplasm bank is, however, one of the most complete in the world and entails considerable work in maintenance and evaluation. Regeneration and evaluation of accessions progressed slowly during recent years. The Panel understood that the information on accessions will now be computerized.

H.26. Since 1976, the Maize Program increased the number of its gene pools from 20 to 33, with the inclusion of special pools for highlands, temperate areas<sup>2/</sup>, high quality protein and early maturity. There has been concurrently a steady flow of new introductions into the pools. The Program, therefore, has considerably increased the genetic diversity of the basic materials while improving them at the same time so as to meet the diverse requirements of its collaborators.

H.27. Twenty-four advanced populations with normal protein quality were developed from the gene pools. The major advantages of these populations over local varieties are high yielding potential, reduced plant height, and other improved agronomic characters. Resistance to downy mildew, corn stunt, and more recently streak virus are now being incorporated in some of these improved populations and for two populations, improved resistance to fall armyworm. Work is in progress in developing

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<sup>1/</sup> The reduction of the tropical maize plant height by nearly 50% is a major achievement in making the crop more efficient in grain yield and responsive to fertilizer with lower risk of lodging.

<sup>2/</sup> As a source of improvement for sub-tropical material.

resistance to earworm and stem borers. Early maturing populations are also being developed. In addition, three advanced populations with improved protein quality and vitreous endosperm grain quality have been developed with nearly comparable performance to CIMMYT's other advanced populations.

H.28. The program of international maize testing which is based on the above populations, and on the experimental and elite varieties derived from them, also expanded from 49 to 84 participating countries since 1976. It now covers nearly all maize producing countries of the developing world. The retrieval and the quality of the data also improved as a result of the training of CIMMYT's cooperators and the support of regional staff. The number of nurseries increased concurrently, providing a wide range of material at different stages of development for adaptation and use by National Programs, including the development of hybrids.

H.29. The above achievements in the development of superior maize germplasm with a wide diversity and the increased demands of national collaborators for CIMMYT's improved materials clearly demonstrate the validity and effectiveness of the breeding scheme which was adopted by CIMMYT in 1973.

### 2.3. Strengthening National Wheat and Maize Programs, including Manpower Development

H.30. During the last quinquennium, CIMMYT continued to offer six-month in-service training courses both in production research and crop improvement (for both wheat and maize, with two cycles in maize and one in wheat conducted annually). In addition, the 2-3 month course for laboratory technicians continued; a new 4-month course in station management and a 3-month course for agricultural economists engaged in on-farm maize and wheat research activities were begun in 1979.

H.31. The training activities have involved 376 maize trainees from 61 countries since 1976 (227 from 1971 to 1975) and 270 in wheat (364 from

1960 to 1975). The practical field orientation of these courses remains unchanged. There was some improvement in the training methodology and curricula, with increased emphasis on on-farm research and seed production, as well as larger inputs from a wider range of disciplines, agronomy and economics in particular. The demands for these courses remain very high and, due to funding limitations, could not be fully met during the last three years.

H.32. CIMMYT continued to assist pre-doctoral fellows in the preparation of their theses on subjects of direct interest to CIMMYT programs. Their number varied from 5 to 22 each year and they remain from 12 to 18 months at CIMMYT. Ninety percent came from developing countries (75% during the last ten years ending in 1976). The number of fellowships sponsored by CIMMYT in universities decreased, however, due to financial limitations.

H.33. Post-doctoral fellows continued to spend one to two years at CIMMYT; while 43 came to CIMMYT from 1966 to 1976, their number averaged 38 during the last five years. CIMMYT made increasing use of post-doctoral fellows for supportive research (e.g. agronomy, wide crosses) and as instructors in the training program. In this last case, their turnover and limited experience in training are, in the opinion of the Panel, a problem deserving further attention, if post doctoral fellows continue to play an important role in guiding the work of the trainees.

H.34. The Panel noted that further progress should be made in the preparation of training manuals in several areas, with some notable exceptions, economics in particular. Finally, it was noted that there were considerable differences in the experience of the trainees participating in a given course and this, along with the language differences with which CIMMYT cannot fully cope, may reduce the effectiveness of training. In spite of this, during its visits to other countries, the Panel witnessed the significant impact of CIMMYT training programs and noted the high praise for them by National Programs.

H.35. In addition to the above training activities at headquarters, CIMMYT during the last six years has increased its contribution to in-

service training at country level in national projects and regional programs. Seminars and workshops organized by CIMMYT at country or regional level have been well attended and appreciated by the participants. The outposted staff of CIMMYT also facilitated the visit of an increased number of visiting scientists at CIMMYT (275) and at research stations in diverse countries in their respective region.

H.36. Other contributions to the strengthening of national maize and wheat programs were made by the frequent visits of headquarters and regional staff providing advice and guidance on the organization and management of national research, helping reduce administrative bottlenecks or providing small amounts of funds for minor essential equipment, in-country travel and other contributions in the day-to-day work of the research program.

H.37. A series of case studies were also developed by the Economics Program in cooperation with the Maize and Wheat Programs as base material for seminars with agricultural policy makers. The objectives of these seminars were to increase the awareness of senior country officials regarding the constraints to agricultural development and the role of agricultural research.

H.38. Through these diverse inputs, several national wheat and maize programs have been greatly strengthened and some have developed efficient breeding and on-farm research programs which received increased support from their governments. Unfortunately, others where CIMMYT had made significant inputs in the past declined sharply due to political changes and/or shortage of funds. Many national wheat and maize programs still have very limited capacities and means, and rely heavily on CIMMYT and other sources in the procurement of improved seeds.

H.39. During its visits to diverse developing regions where CIMMYT's staff are outposted, the Panel had ample evidence of the important contributions made by CIMMYT's training programs, its regional programs and national projects. The wide differences in the situations met, however,

suggest the need for a regional diversification and more selectivity in CIMMYT's mode of operations for strengthening national wheat and maize programs. While regional programs have generally proved effective, they have to be supplemented or, in some regions, could be replaced by other forms of cooperation and assistance such as national projects, as well as collaborative research arrangements with CIMMYT headquarters or within the region. In deciding among different forms of involvement, the Center should continue to take into account the degree of development of the National Programs and the support which other IARCs, other agencies and some advanced National Programs themselves can provide.

#### 2.4. Development of Research Methodologies and Techniques

H.40. The overall breeding methodologies of CIMMYT remained basically unchanged during the last six years, thus providing the necessary continuity to the programs. Several improvements were introduced, however, such as: the use of shuttle breeding with a growing number of countries for specific problems; the larger use, through the regional programs and national projects, of research sites outside Mexico for screening and development of material resistant to insects and diseases not prevalent (or not important) in Mexico; the further development of methodologies for the use of temperate germplasm in sub-tropical regions (the spring x winter wheat crosses and the introgression of temperate material in sub-tropical maize populations); the further elaboration of the overall maize breeding scheme based on a wide range of specific gene pools and the improvement of open pollinated populations; procedures and techniques for improved maintenance and efficient seed production of open pollinated maize varieties in developing countries; and the development of methodologies for producing hybrids at national level starting from the maize populations provided by CIMMYT.

H.41. Several very effective techniques were developed and incorporated into the breeding program in order to screen better for insect resistance in maize. A program was initiated in screening for tolerance to drought in the field and progress was made to screen for resistance to aluminum in laboratory conditions. Further progress seems necessary,

however, in the development of methodologies for screening and breeding for tolerance to a wider range of environmental stresses and adverse factors (salinity in particular), and for the integration of agronomic performance in breeding goals especially in sub-optimal management conditions.

H.42. Another major advance in the development of methodologies was made in publishing a manual on procedures for assessing new maize and wheat technologies<sup>1/</sup> and another manual on on-farm research<sup>2/</sup>. The former publication has been very widely translated and disseminated.

H.43. These methodologies and techniques listed above are demonstrated in the training programs and several of them have been adopted in the National Programs. Much more would have been gained by publishing, translating and widely disseminating these results in scientific journals and/or as training materials, in particular the overall methodology, breeding scheme, and selection results of the Maize Program.

## 2.5. Advances in Knowledge and Its Dissemination

H.44. CIMMYT as an institution involved mostly in applied research and practical improvement of wheat and maize production does not carry out by itself major activities in basic research. Nevertheless, it can claim to have contributed a number of advances in knowledge during the last quinquennium both through its own staff (mostly at headquarters) and through research contracts and collaborative arrangements. For example:

- (i) Demonstrated that opaque-2 genes can be incorporated to improve protein quality in maize, without sacrificing yield

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<sup>1/</sup> "From Agronomic Data to Farmer Recommendations - An Economic Training Manual", by R.K. Perrin, D.L. Winkelmann, E.R. Moscardi, J.R. Anderson, CIMMYT, 1979.

<sup>2/</sup> "Planning Technologies Appropriate to Farmers - Concepts and Procedures", by D. Byerlee, M. Collinson, et al., CIMMYT, 1980.



- and grain quality, through understanding of the action and stability of a group of modifier genes.
- (ii) Elucidated the role of shorter plant types and other morphological features in relation to grain yield efficiency and earliness in maize.
  - (iii) Documentation, by wide-scale surveillance methods, of the origin and extent of distribution of specific races of wheat pathogens. This makes possible the control of epidemics by strategic deployment of varieties resistant to different races of the pathogens, and it provides guidance to breeders concerning the types of resistance to diseases needed in different regions.
  - (iv) The observation of slow-rusting characteristics in some CIMMYT wheat varieties which may provide more stable protection against leaf rust.
  - (v) Demonstration, that specific wheat varieties (Veery lines) which contain parts of rye chromosomes also have extremely high yield potential and broad adaptation.
  - (vi) Demonstration that triticale varieties can be developed with acceptable grain quality, and yields that are superior in specific production environments to the best wheat varieties.
  - (vii) Accomplished several intergeneric hybridizations of wheat with Elymus, Agropyron, and barley; identified the chromosomes that had been transferred using cytological techniques; and produced wheat plants which have additional alien chromosomes that can be evaluated for resistance to specific diseases and stresses.
  - (viii) In the field of economics, several important publications were issued (including a review of the basic statistics and trends in wheat and maize production, consumption and trade) which provide a broader basis for programming and priority setting at CIMMYT.

H.45. Due to work pressure in the very tight operations schedule of the programs and to CIMMYT's practical field orientation for the improvement of production in developing countries, however, the opportunity for dis-

disciplinary research at CIMMYT and the time made available for compilation and analysis of data, and for publishing results, remain limited.

## 2.6. Impact on Wheat and Maize Production

H.46. The impact of CIMMYT's technologies (principally improved varieties) on wheat and maize production during the last five years is difficult to assess. The number of varieties released with CIMMYT background material is an indicator of the interest of countries in CIMMYT technologies and provides an idea of the potential impact of CIMMYT. The degree of adoption of these varieties by farmers and the achievement of their full potential by appropriate management depend on many factors and, to a large extent, on many local conditions. The Panel was not provided with an analysis which would identify the contributions made by CIMMYT's technologies as distinct from the contributions made by other sources such as increased fertilizer use, irrigation, changes in land use, influence of prices, etc. While CIMMYT had made some adoption studies in the mid-seventies, limited work has been done to assess the impact of the Center during these last five years on which the Panel could draw general conclusions. A few indicators, examples and estimates can, however, give an idea of the impact of CIMMYT during the last quinquennium.

### 2.6.1. Wheat

H.47. As regards wheat, CIMMYT estimates that some 50% of the bread wheat areas of the developing world is covered by varieties which were developed with CIMMYT germplasm in their pedigree. Setting aside the interactive effects of other inputs and management, CIMMYT estimates that the use of these varieties is adding some six to seven million tons of wheat annually in the developing world. In addition, many wheat varieties now widely used in North America, Europe and Australia have been developed using CIMMYT material.

H.48. During visits to several countries, members of the Panel had the opportunity to observe the impact of CIMMYT-derived varieties on wheat

production. For example Sonalika is now grown on some 10 million hectares in the Indian sub-continent. The rapid adoption of an early maturing variety of wheat in Bangladesh enabled the rotation of rice with this crop and a considerable rise in production from less than 0.2 million to one million tons during the last five years. Similarly, recent varieties derived from winter and spring crosses have been widely adopted as they have both a high yielding potential and a large degree of resistance to diseases and various stresses. Meanwhile, countries continue to ask for increasing amounts of seed from CIMMYT for developing superior varieties.

H.49. The work on triticale, which appeared still somewhat speculative five years ago, now has clearly demonstrated its potential if not yet a real impact on production. The Panel has no doubt that along with the growing number of varieties released in developed and developing countries, and once some marketing difficulties are resolved at the national level, this crop will have a considerable future.

#### 2.6.2. Maize

H.50. As regards the impact of the Maize Program of CIMMYT, it should be first recognized that the Program is relatively younger than the Wheat Program and deals with a cross-pollinated crop often used in subsistence farming where gains are less easy to obtain, measure and maintain. Moreover, the crop is grown under a diversity of environments and farming conditions and a wide variety of consumer requirements. The impact of CIMMYT-derived varieties on production is, therefore, more difficult to assess. CIMMYT reports that approximately 5 million ha of varieties based on CIMMYT germplasm are now grown in the developing world. The approximate breakdown is as follows: 1.0 million ha in Asia; 0.5 million ha in each of the following areas: South America, Central America (excluding Mexico) and Africa. The remaining 2.5 million ha are grown in Mexico.

H.51. The fact that about 70 maize varieties (of which 25% are hybrids) have been released in the last three years in 22 countries and that demand for seed increased two-fold in 1981 is very encouraging. The crop, however, suffers from a large number of adverse factors, in par-

ticular the problem of weeds in the tropics, several insect pests, the vulnerability of some CIMMYT-derived varieties to diseases as the husk is too short sometimes to protect the ear, and above all the difficulty of organizing efficient seed multiplication and delivery systems to the farmers. Nevertheless, the Panel is confident that the progress made to date by CIMMYT, and its impact so far, largely justify the modest financial investments made during the last ten years and warrant continued strong support.

H.52. As to the impact of the quality protein maize program, it seems premature to draw conclusions from the interest shown locally in the use of the QPM material. As indicated in section 7 of Chapter D, some research problems must be solved, and in particular the ways and means by which this material will be disseminated and maintained should be further tested. The nature of potential markets and beneficiaries of the program also require clarification.

#### 2.6.3. Future Outlook

H.53. The considerable impact of CIMMYT's programs may lead to questions as to the feasibility of their further progress and impact, especially as regards wheat. While recognizing the importance of this impact, it should be stressed that production is still far from meeting the demands in many countries (e.g. North Africa, Near East and Middle East) and that countries which are reaching or will soon be reaching self-sufficiency are subject to considerable annual variations in their production due to climatic stresses and diseases to which the CIMMYT material is potentially vulnerable (although significant progress is being made). Moreover, in several countries, production has decreased as a result of different factors, including in some cases a slow-down in the national research effort. As indicated in the next chapter, there are therefore a number of continuing tasks and new challenges for CIMMYT as regards wheat and maize production.

### 3. Constraints, Gaps and Related Problems during the Past Quinquennium

H.54. Although CIMMYT's achievements since 1976 are very impressive, the impression should not be given that the results were obtained without facing some serious constraints. There were difficult choices for CIMMYT among multiple demands and priorities and therefore some gaps were left unfilled and some problems remained unresolved. As indicated in Chapter B, there have been serious limitations in the availability of funds to CIMMYT since 1979 <sup>1/</sup>. These limitations had serious effects on the further development plans of CIMMYT which were recommended by the first quinquennial review, and further elaborated in the long-term plan published in 1980. This also created some further constraints and gaps in the existing priorities and programs. In addition, several problems could not be resolved which are inherent to the present structure of the CGIAR system and/or to the nature of the problems faced by National Programs in developing countries.

#### 3.1 Constraints Due to Limitations in Available Resources and in Their Deployment

H.55. CIMMYT has not yet fully adjusted its structures and programs to the repeated financial shortfalls experienced since 1979. In fact, both the first quinquennial review in 1976 and the 1979 long-term plan anticipated a moderate growth of the program. Should this financial situation persist, some of the imbalances which developed between the size and the number of the regional programs and the strength at headquarters should be re-examined. The development of off-campus activities has put a considerable burden on the limited staff at headquarters in terms of overall supervision, supporting services, communications and travel. The headquarters staff has been reduced to a very minimum and vacancies have created serious problems. The vulnerability of the programs at headquarters to vacancies and turn-over was exacerbated by unpredictable

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<sup>1/</sup> Shortfalls and delays in funding the approved budget requests, for example.

shortfalls in funding, and this problem tended to persist as most of the sub-programs were manned by a single senior scientist. Moreover, several vacancies in senior staff had to be filled temporarily by post-doctoral fellows and this resulted in some limitations in the effectiveness of the programs in training and in supporting research and services. In addition, the number of trainees and fellowships had to be curtailed.

H.56. Should the present financial stringency persist, CIMMYT may have to review the deployment of its resources, in particular the priority given to the further growth of various regional programs. Overall, the Panel feels that, due to unforeseen circumstances, the staff resources of CIMMYT may become over-extended and over-burdened by a very heavy schedule of operations, travel and multiple demands on their time and competence.

### 3.2. Constraints and Gaps Due to Present Internal Policies, Priorities and Structure

H.57. In the above-described conditions, there were few opportunities for CIMMYT to broaden the scope of its programs in disciplinary research, to take wider responsibilities in germplasm conservation, or to expand data analysis and its work in communications and publications. Nevertheless, it seems that the gaps and limited progress which were found by the Panel in some of the above areas were also due to a deliberate policy on the part of CIMMYT to attend to the most immediate and pressing needs of developing countries for improved wheat and maize production in line with the interpretation given to its mandate and, in the circumstances, to give lower priority to activities which may be considered of a more long-term or speculative nature. Moreover, the program structures and their workload gave limited opportunities for flexibility and interactions among scientists under the prevailing financial constraints. The Panel recognizes that the choices and decisions which were made in these circumstances were appropriate. The Panel, however, would encourage CIMMYT to continue introducing changes in its priorities and programs in spite of its present financial constraints. Several recommendations were made to this effect in the

preceding chapters and their feasibility under different funding scenarios is discussed in the next chapter.

### 3.3. Constraints in CIMMYT Relationships with National Programs and Other IARCs

H.58. Some other constraints and obstacles which were faced by CIMMYT during the last quinquennium were largely due to external factors over which CIMMYT had little control. At national level, existing policies, institutional structures, lack of resources and inputs, insufficient coordination between research, extension, and production programs sometimes limited the impact of CIMMYT activities. In several instances, CIMMYT staff were successful in inducing changes and overcoming these obstacles. The Panel would, however, caution CIMMYT against too broad an interpretation of its mandate regarding its role in achieving higher and better wheat and maize production worldwide. The Panel agrees with CIMMYT Board's decision to pass to ISNAR the responsibility of holding seminars for policy makers. Similarly, CIMMYT has shown that it can sometimes play an important catalytic role in improving seed production at national level and facilitating research linkages with extension through on-farm research and training. Nevertheless, CIMMYT scientists should guard against an excessive involvement in operational and managerial responsibilities or direct association with internal institutional/structural changes in areas extending beyond wheat and maize research at national level.

H.59. As regards the relationships with other Centers, some cooperative arrangements seem to work well, others are still constrained by some problems of personality which should be left to the Directors General concerned to resolve. There are, however, some more fundamental issues which are inherent in the existing mandates of the respective Centers, and to the interpretation given by them as to their global and regional responsibilities for certain crops and for farming system research. The Panel feels that these problems cannot be resolved merely by consultations and ad hoc arrangements between the Centers concerned but call for strategic readjustments so as to ensure better coordination and effectiveness of the CGIAR system.

## CHAPTER I

CIMMYT'S LONG-TERM PLAN -  
OBSERVATIONS AND RECOMMENDATIONS1. Preliminary Remarks

I.1. The Panel examined both the long-term plan which CIMMYT had published in 1980<sup>1/</sup> and a document<sup>2/</sup> on the optimal size of CIMMYT prepared by the Director General for the quinquennial review. In discussing these proposals, the Panel first reviewed the premises on which future plans should be based, namely the present and future world situation regarding wheat and maize, the past achievements of CIMMYT and its comparative advantages for the future, its potentialities for impact, its short-term and long-term functions, and the Panel's observations and recommendations regarding CIMMYT's mandate and strategies and its programs for the next five years, as presented in the preceding Chapters.

I.2. The Panel's discussions of CIMMYT's long-term plan were also necessarily influenced by financial considerations. The Panel did not wish to prejudge the future levels of financial support which the Center could or should obtain. However, in the light of past experience, it felt that the implications of several funding scenarios should be examined and that it was incumbent on the Panel to draw the attention of CGIAR/TAC and that of the governance and management of CIMMYT to diverse alternatives and their consequences before making its final recommendations.

2. The Basic Premises of CIMMYT's Plans for the Next Five Years

I.3. The Panel generally agrees with the findings of the analysis which CIMMYT has made of the future global requirements for wheat and maize,

<sup>1/</sup> "CIMMYT Looks Ahead - A Planning Report for the 1980's", CIMMYT, 1980.

<sup>2/</sup> "Optimum Size of CIMMYT" CIMMYT, 31 August 1982.



the significance of wheat and maize in the human diet, and the major gaps which can be anticipated in the next decade as the human population continues to grow in developing countries. The Panel recommends that this global analysis should be further elaborated in the light of the information recently acquired by CIMMYT<sup>1/</sup> on the changes in production, consumption, trade and prices for maize and wheat over the last two decades, by countries and by region, and recent prospective studies by FAO, the World Bank, IFPRI and others. The Panel also recommends that this analysis should be supplemented by an identification and delineation of the different agro-ecological areas with respect to their wheat and maize potentials and production constraints. In the view of the Panel, it is essential that a world center for wheat and maize have such information on hand as a guide for formulating its priorities and strategies in different regions. The compilation of this information could be initially carried out by a special project or through collaborative research. Its periodic updating, however, should be a core function of CIMMYT and involve the senior staff of its three main programs, who by their frequent travels continuously monitor the changes in the maize and wheat situation in the developing world.

### 3. Comparative Advantages, Future Mandate and Clarification of Functions of CIMMYT in the 1980s

#### 3.1 CIMMYT's Comparative Advantages

I.4. The initial mandate of CIMMYT gives the Center the task of promoting the improvement of wheat and maize production world-wide. However, the Center recognizes - and the Panel agrees - that its main target should continue to be the developing countries, and that its main comparative advantage is in the development and distribution of superior germplasm via international testing and analysis of the substantial amount of data flowing to it. Complementary to this major comparative

<sup>1/</sup> "World Wheat Facts and Trends 1981" and "World Maize Facts and Trends 1981", CIMMYT, 1982.

advantage are CIMMYT's strengths in breeding methodology, training orientation and, in particular, the availability of a system of excellently managed and very well-sited research stations, backed up more recently by the installation of significant computing capacity.

I.5. The impact of CIMMYT's superior germplasm depends on many factors and constraints. There are only a few of these factors which CIMMYT can influence to any significant extent through its provision of research and training in maize and wheat breeding, agronomy and economics, and its related activities in communication. Many important factors which constrain the impact of CIMMYT's germplasm lie outside of CIMMYT's control, influence or responsibility - for example, such factors as national policies, institutional structures, extension and delivery services; fundamental research; and farming systems research. There are some "grey areas", however, where the future role of CIMMYT needs further clarification or consideration.

### 3.2 Clarification of Functional Tasks

I.6. Areas in which the Panel believes some clarification or reconsideration of CIMMYT's role is needed are germplasm conservation, agronomy and on-farm research, seed production, advisory services, and - in terms of rearrangement - training.

I.7. Germplasm Conservation: CIMMYT essentially maintains working collections of material which it considers useful to its crop improvement programs. It also co-sponsors with IBPGR the two international committees on the genetic resources of wheat and maize respectively. As it has increased its storage capacity and the number of accessions considerably, it can play an increasing role in germplasm conservation. However, systematic regeneration and evaluation of material would be a considerable burden on the staff of the Center and would compete for funds with its more production-oriented activities. It could be argued that an IARC with a global mandate for wheat and maize should take more long-term responsibilities in germplasm conservation, at least for the material which originates from or is of interest to sub-tropical and tropical areas. This cannot be achieved in the present funding conditions, however. The Panel notes that

IBPGR, in association with other international and national institutions concerned, has assigned definite responsibilities for the long-term conservation of maize and wheat germplasm, but action is needed to accelerate evaluation. Meanwhile the Panel recommends that CIMMYT continue: to maintain its wheat and barley working collections and its maize germplasm and triticale germplasm banks; to pursue its evaluation work; and to acquire new accessions and some additional storage facilities as may be required by its wide-cross and germplasm development programs.

I.8. Agronomy and On-Farm Research: The Panel recognizes that the continued development of improved characters and agronomic practices for CIMMYT material will be essential to the realisation of high yields by CIMMYT-derived varieties in farmers' fields, particularly as production extends into more difficult environments. The Panel recommends that the future role and function of agronomy at headquarters and in off-campus activities of CIMMYT should be better defined. The Panel sees the functions in agronomy and on-farm research at headquarters as essentially confined to (a) development of general principles, knowledge and methodologies for improved crop management; (b) training and (c) support services to breeding programs and station management. The role of agronomy in CIMMYT off-campus activities is more difficult to define as it has a large degree of location-specificity and overlap with the responsibilities of National Programs and other Centers (in particular in farming systems research and training). The Panel recommends that CIMMYT should continue to examine the role of the agronomists in its regional programs in consultation with the other IARCs and National Programs concerned, and seek cooperative arrangements in both research and training. Both at headquarters and in off-campus activities, the Panel recommends closer integration of the disciplines concerned (agronomy, economics, and, in some cases, soil science, physiology and farming systems), involving not only CIMMYT staff but also other Centers' and national staff as appropriate. Except for its role in training, the Panel considers that the responsibility for liaison and cooperation between research and extension in National Programs is not CIMMYT's but a national one.

I.9. Seed Production: The Panel is concerned by the limitation which inadequate seed production imposes on the impact of CIMMYT-derived varieties in many developing countries. It would, however, caution CIMMYT against too broad an involvement in seed production technology, organization and distribution. The Panel recommends that CIMMYT should continue to assist national breeding programs to play a more active and continuing role in the production of breeder seed and in the provision of technical advice on efficient and rapid methods of multiplication, and on quality control, to the national institutions concerned with seed production.

I.10. National Policies and Economics: The Panel supports CIMMYT's decision to hand over to ISNAR the activity of presenting seminars for policy makers, and renews the recommendations of the first review Panel cautioning CIMMYT against too deep an involvement in providing advisory services to governments on economic policies and institutional changes in overall research, extension, development and marketing structures.

I.11. Disciplinary Research: The Panel endorses the present policy of the Center by which it seeks a growing number of appropriate collaborative arrangements with advanced research institutions in developed and developing countries. Although it sees CIMMYT essentially as an applied research institution focusing mainly on plant breeding, the Panel recognizes the need for CIMMYT to maintain at headquarters a competent capacity in the relevant scientific disciplines in order to make best use of collaborative research findings and support the crop improvement and training programs.

I.12. Training: The Panel recognizes and endorses the emphasis placed on in-service and other modes of training by CIMMYT in its various programs. CIMMYT enjoys a comparative advantage in its in-service training courses and the Panel would like to direct attention to strengthening this activity. It was the Panel's finding that increased support was needed to most aspects of training, including facilities, instructional materials and, for wheat, a more stabilized staffing plan. It was the Panel's understanding that most courses were currently at

their enrollment limit. There are many bilateral programs in wheat and maize in developing countries which could make use of their provision for training by involving CIMMYT training opportunities to a larger extent. CIMMYT could then in turn expand further its training facilities.

I.13. All told, CIMMYT's annual training activities involve eleven separate courses. These encompass:

- Economics
- Crop Improvement (Maize; Wheat)
- Crop Production (Maize; Wheat rainfed, irrigated)
- Pathology (Maize; Wheat)
- Cereal Quality and Technology (Maize; Wheat)
- Experiment Station Management.

I.14. The Panel recommends the expansion of the in-service training activities and their coordination into a Training Program. This Program would have a Director of Training and a staff of Training Officers, having assignments in the Wheat, Maize and Economics Programs, with full-time training responsibilities. In addition, some members of the research staff of the various programs would have continue to have part-time instructional assignments such as lectures in climatology, soils, statistics, etc. The Training Program would utilize common instructors insofar as possible in the maize and wheat courses. The Director of Training would provide administrative support to the trainees and all courses; assist in arranging funding support for special training activities, including facility development; and of course, contribute directly to instruction. He would also ensure follow-up liaison with ex-trainees, particularly those having a training function. He would cooperate closely with the economics and crop programs in the development of training curricula and training materials, the scheduling of training courses and related field activities, and in the selection of trainees.

I.15. The Panel further recommends that CIMMYT plan for additional classroom/laboratory facilities in order to alleviate current limitations and

to accommodate larger numbers of trainees. The Panel is optimistic that donors could be identified to contribute the necessary funds.

I.16. In-service training on a regional and country basis has been suggested as also a valuable training mechanism. The Panel is supportive of such training efforts, but believes they should be carried out in cooperation with other relevant institutions so as, when necessary, to overcome any limitations CIMMYT may have in terms of language capability or lack of familiarity with local agricultural conditions.

### 3.3 Mandate Revision

I.17. The Panel recommends that CIMMYT's mandate be revised and updated. This should be done in the light of the present functions of CIMMYT and of the Panel's observations presented above (and with more details in Chapter B). Moreover, as indicated in Chapter B, the Panel recommends that the Center take further steps in the re-examination of its legal status in Mexico so as to bring CIMMYT to a position similar to that of other IARCs in their host country, while preserving the special links and the excellent cooperation and essential support facilities which CIMMYT enjoys from its host country.

I.18. As regards the basic functions which CIMMYT should continue to perform in discharging its mandate, the Panel recommends that CIMMYT pay more attention to the long-term functions and services which the Center will be increasingly asked to provide as the National Programs of developing countries increase their competence and seek a larger degree of self-sufficiency. The Panel believes that the basic services which the Center will be asked to fulfill on a long-term basis are essentially:

- first and foremost, germplasm development (including related disciplinary research requirements) and its distribution as parental material and gene pools;
- the distribution of specialized nurseries including sets for disease surveillance;
- the development of new research techniques and methodologies;
- the holding of specialized seminars on scientific advances and new problems of international or regional importance;

- the dissemination of information including compilations of literature on key subject matters; and
- the provision of training with increasing emphasis towards specialized areas.

I.19. For the time being, however, the Panel recommends that the Center (a) should continue to perform as a priority its essential functions in breeding improved material in collaboration with National Programs, so as to maintain and expand the substantial and promising gains already obtained; and (b) should continue a vigorous program of manpower development at various professional levels for the national wheat and maize programs in developing countries. The Center should, however, be expected during the coming quinquennium to begin to shift gradually its activities towards its more long-term functions alluded to above, particularly in wheat and ultimately in maize.

#### 4. Future Strategies

I.20. The Panel generally supports the strategies outlined in CIMMYT's long-term plan for the 1980s. The Panel recommends, however, that these strategies be applied by CIMMYT in such fashion as to take account of the diversity in the stages of development of National Programs, and their interest in mounting regional and sub-regional cooperative ventures. The Panel supports the first steps which CIMMYT has taken in these directions. It encourages the Center to apply greater selectivity in determining the number and scope of its international nurseries, and also in responding to different training requirements at international, regional and national levels, while maintaining the necessary cohesion and close interaction among its activities world-wide.

#### 5. Discussion of CIMMYT's Future Plans in Relation to Resource Requirements and Alternative Program Structures

##### 5.1 Implications of CIMMYT's Planning Report for the 1980s

I.21. The long-term plan of CIMMYT, as established in 1980, essentially foresaw an expansion of CIMMYT's activities along the lines and within

the structures which prevailed at the end of the 1970s <sup>1/</sup>:

(a) at Headquarters:

- (i) A slight decrease in the Wheat Program (22 international positions in 1980, 20 in 1986 with a decrease in each of durum wheat and triticale from 2 to 1 and agronomy from 3 to 2).
- (ii) No change in the number (18) of Maize Program positions.
- (iii) An increase of one (from 3 to 4 positions) in the Economics Program.

(b) in Regional Programs:

- (i) The regional wheat program positions were expected to double from 9 to 18, with the opening of a new program in Asia.
- (ii) The regional maize program positions were expected to increase from 10 to 14, with the opening of a new program in the Southern Cone.
- (iii) The economics regional program positions were expected to remain constant at 5, but the East African and the Andean programs were expected to be closed in 1986, while two new programs were expected to be launched in Southern Asia and Southern Africa.

I.22. Although these plans have been largely overtaken by events as the planned positions for 1980 could not all be filled due to resource constraints, the deployment of staff as initially proposed calls for several observations and recommendations by the Panel:

- (i) The balance of future positions between the Maize and Wheat Programs seems to indicate more strengthening in wheat than in maize, especially in regional programs, whereas from the assessment made by the Panel it seems that the Maize Program is now gaining momentum and would deserve relatively more resources to increase and spread its impact.
- (ii) The number of positions in training would remain constant. The Panel, on the contrary, as described in section 3.2 above recommends the establishment of a Training Program which would integrate and expand present training activities. The Panel also recommends the appointment of a Director of Training.

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<sup>1/</sup> All positions referred to in this chapter are international core-staff positions.



- (iii) With the exception of the Middle East, the regional programs within each crop were expected to have about equal strength in 1986 and therefore apparently deserving the same priority. While recognizing that this approximate equality in staff allocation within Programs across regions arises in part from the desire, on efficiency grounds, to have a team of at least two staff in each region, the Panel feels (and as discussion with the Directing Staff also indicated) that some regions deserve priority while some other form of collaborative arrangements could advantageously replace a regional program in others where several National Programs are particularly strong and are reaching self-sufficiency or even surpluses in one or the other crop.
- (iv) The proposed change in the pattern of regional economic staff between regions needs to be evaluated in terms of both its rationale and the feasibility of having close and continued interaction of regional economists with the maize and wheat regional staff.
- (v) There is very little provision in the long-term plan for any further strengthening in disciplinary research. This is not consistent with the Panel's view concerning needs with respect to the long-term functions of CIMMYT.

I.23. Should the resource requirements anticipated by this plan be met (either by core or non-core funds), the Panel would recommend that the plans be revised taking into account the above observations and the related comments and suggestions made in the preceding Chapters. In addition, the Panel would encourage CIMMYT to continue to involve itself in selected national projects, particularly in the regions where National Programs require strengthening, and to provide limited advisory and training services to appropriate projects operated by bilateral or multilateral agencies.

## 5.2 The "Minimum/Optimum" Alternative Plan<sup>1/</sup>

I.24. As the Center has experienced repeated funding shortfalls since 1979, it was unable by 1982 to reach the staffing levels projected in

<sup>1/</sup> "Optimum Size of CIMMYT", document prepared for the Quinquennial Review Team, 31 August 1982. (See extract in Annex VI.)

its initial plans for 1980-86 and even had to remain below those expected in 1980. As the budget stringency may continue for some years, CIMMYT's Director General prepared an alternative proposal for the Panel's consideration, called a "minimum/optimum model" with comparative tables relative to the initial long-term plan and the budget for 1980 (approved) and 1983 (recommended).

I.25. The "minimum/optimum model" as compared to the initial long-term plan for 1986 shows the following differences:

- (i) a reduction of size in all of the regional wheat programs except for the cooperation with ICARDA and in disease surveillance;
- (ii) a reduction by one position (wide crosses, 1 instead of 2) of the Maize Program staff at headquarters, whereas the Wheat Program staff at headquarters would remain that foreseen by the initial long-term plan;
- (iii) the deferment of the Southern Cone maize program and the strengthening of that of Central America and the Caribbean;
- (iv) a reduction by one position in the economics staff at headquarters, and a reduction of one position in the economics regional program with some rearrangement in the deployment of regional economists.

I.26. The Panel observations on this "minimum/optimum model" are in general similar to those made on the initial long-term plan. In particular, relative to this minimum/optimum model, the Panel recommends that CIMMYT gives serious consideration to a more selective deployment of the wheat regional staff, with some further reductions which should enable funds to be provided for other priorities. The Panel agrees with the proposal to defer the Southern Cone maize program if resources become more limited, and would encourage the consideration of similar selective moves in the regional wheat programs. In addition, the Panel recommends that CIMMYT, in consultation with other Centers concerned, give serious consideration to the possibility of joining forces so as to constitute inter-IARC teams at the regional and national level, in particular in the fields of agronomy and economics. This, and possibly the saving of one position in wheat pathology at headquarters, may enable some further

economies which could provide funds for meeting several additional requirements which the Panel considers essential at headquarters. Within its concept of an appropriate "minimum/optimum model", the Panel suggests the following order of staffing priority but recognizes that Management will need to exercise flexibility in taking advantage of opportunities for appointment:

- one crop physiologist/agronomist to serve both the Wheat and Maize Programs;
- a Director of Training;
- a senior breeder with competence in quantitative genetics in the Maize Program;
- an additional senior breeder/geneticist in the Wheat Program;
- a statistician/computer scientist;
- an additional maize pathologist.

### 5.3 Funding the Additional Requirements

I.27. Ideally, if there were no financial constraints, these six additional positions should be funded by additional core support. Should the core resources of CIMMYT not be sufficient to meet all the additional requirements indicated above, the Panel would suggest that the Center consider the possibility of achieving core savings by reducing the number of staff positions in selected regions and by funding the activities of some regional programs via special projects and/or to replace some of these by national projects supported bilaterally. The Panel would consider it essential that such possibilities be explored so as to secure the establishment of the following additional core positions at headquarters: director of training, maize breeder, wheat breeder, and statistician/computer scientist. In such circumstances, the other additional positions recommended by the Panel could be filled by seeking collaborative arrangements with advanced research institutions such that they would outpost staff at CIMMYT for at least three and preferably five years. In making these suggestions as to priority and mode of funding, the Panel again recognizes that Management would need to have flexibility in implementation.

## 6. Alternative Structural Adjustments in Case of Major Changes in the Funding Level of CIMMYT and in the CGIAR System

### 6.1 A Plant Breeding Institute

I.28. In case of major resource shortfalls, CIMMYT could move more quickly towards what may be its most essential role in the long term, i.e., purely a plant breeding institute involved in germplasm development and distribution with a minimum core of supportive basic research and specialized training functions in breeding. In the near term, this would create a severe set back in most of the developing regions, particularly in maize and also, to a lesser extent, in wheat. In such a circumstance, it would be essential that serious consideration be given to reinforcing other appropriate IARCs in cereal agronomy and on-farm research and related training, especially those having a mandate for certain agro-ecological zones and farming systems research. In addition, a considerable effort would have to be deployed by bilateral and multilateral agencies to compensate for the reduction (or cancellation?) of CIMMYT's regional programs by launching national wheat and maize research and production projects.

I.29. The Panel would strongly recommend against this alternative of being solely a plant breeding institute. It would create serious gaps and discontinuities in the present efforts to raise wheat and maize production in developing countries and lose the momentum promoted by CIMMYT at the national level, particularly in maize for which the momentum now achieved carries great potential.

### 6.2 A Center with Three Departments: for Maize Breeding, Wheat Breeding, and Wheat and Maize Production Research and Training

I.30. Another alternative structure for CIMMYT would be to have two separate Maize and Wheat Breeding Programs, as in section 6.1 above, and a joint maize and wheat Crop Production Program covering the agronomy, economics and related training aspects for both crops (alternatively, there could be a separate Training Program). The three programs at headquarters would

have staff outposted in the regions, principally at the headquarters of other Centers to work with their cereal and farming system programs. This structure would give more focus on production research and training (including on-farm research and seed production) at a time when many National Programs need more assistance in these fields rather than additional improved germplasm and assistance in breeding. It could, however, weaken the essential links between breeding and agronomy and may restrict the possibility for CIMMYT to make further advances in developing material for difficult environments where close cooperation with agronomy and on-farm research is essential. The Panel finds merit in this structure but considers that it would not be appropriate to implement it at this time.

## 7. Conclusions

I.31. Having considered the alternatives presented above, on balance and without prejudging the broader structural changes which may intervene in the CGIAR system<sup>1/</sup>, the Panel would strongly recommend the adoption of the amended "minimum/optimum model" with the substantial adjustments and additions indicated in sections 4 and 5 above, and does not recommend other major structural changes such as those described in section 6 above, for the time being.

I.32. Further, the Panel strongly recommends that CIMMYT should receive during the coming quinquennium the financial support required to ensure implementation of the amended "minimum/optimum model" along with the related recommendations presented by the Panel in this Report.

I.33. The Panel is convinced that the above recommendations on the future plans of CIMMYT and their funding are fully justified by the impressive achievements of the Center during the past quinquennium and its potential for further impact on wheat and maize production in the developing world.

<sup>1/</sup> For example, a further "regionalization" of the mandates of the IARCs limiting their global crop mandates to germplasm development and distribution.

ACKNOWLEDGEMENTS

The Quinquennial Review Panel members found the task of reviewing this major Center to be a formidable but exciting assignment. The preparation and support given to the Panel by the directing, scientific and service staff throughout the entire review process was outstanding. Various members of the Panel visited CIMMYT outreach programs and were assisted greatly by the careful planning of CIMMYT's staff and local hosts. Without such careful attention to those arrangements, the review would have been very difficult indeed.

During our extended review at CIMMYT headquarters in Mexico all staff were extremely cordial and responsive to our needs for information and services. We want to acknowledge especially Ms. Linda Ainsworth, Head of the Visitor Service, Mr. Chris Dowswell, Communications Coordinator, and their staffs, for their prompt attention to our needs in local arrangements and report preparation.

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LIST OF QUESTIONS SUPPLEMENTING THE TERMS OF REFERENCE  
PROVIDED BY TAC

1. What was the impact of the recommendations of the first quinquennial review?
2. How is the concern for the small farmer reflected in the crop improvement programs, the breeding strategies and the cooperative programs in particular?
3. What is the process of planning and programming of CIMMYT, in particular the priority setting across programs? What role is played by the beneficiary countries of CIMMYT's activities in priority setting and program formulation? What is the economics program's contribution to the formulation of objectives and priority setting?
4. What are the main priority shifts (and their rationale) across programs for the next five years, in particular the changes in the relative importance of commodity research programs, economics, training and communication; between basic and applied research; between on-campus and off-campus activities?
5. What should be the priority regions for CIMMYT's activities in the future?
6. Will the breeding strategies of CIMMYT change as a result of new techniques?
7. Will the cooperative programs of CIMMYT change as national research capacities increase?
8. Should plant protection aspects be strengthened?
9. Durable resistance to pathogens and pests would be desirable in wheat and maize. Is this an objective of CIMMYT's breeding programs and how are the programs organized to attain it? What is the place of integrated pest and disease management in CIMMYT's programs?
10. To what extent in the maize and wheat programs might there be conflicts in breeding objectives such as attainment of higher yields and yield stability, better response to inputs and tolerance to climatic stresses, pest and diseases? How were the programs and methodologies designed to overcome these conflicts?
11. Should CIMMYT give greater attention to characterizing the various rainfed environments under which a large part of wheat and maize are grown in developing countries and their related farming systems?



12. What changes have taken place and are anticipated in the objectives of the socio-economic research programs of the Centres? How does this program integrate with and influence other research programs of CIMMYT and other institutions concerned, in and outside the CGIAR system?
13. In view of the increasing strength of the breeding activities in the national programs, is there now in the revised program structure of CIMMYT an adequate balance between the different aspects of basic and mission-oriented research, in particular as regards plant breeding and other activities, such as soil-water-crop management and socio-economics?
14. What is and should be CIMMYT's involvement in maize research in Africa and Latin America in relation to the programs of IITA and CIAT? What are the specific relationships and working arrangements of CIMMYT with IITA and CIAT at their respective headquarters and in their off-campus activities? What interactions exist or are planned between CIMMYT and ISNAR, IBPGR and IFPRI?
15. What are the relationships of CIMMYT and ICARDA and how are they expected to evolve?
16. How are nutrition considerations taken into account in CIMMYT's present and future programs? In particular, what should be the importance of protein quality maize program within the total program of CIMMYT?
17. What is the optimum number, size and arrangement of the international nurseries and cooperation networks which CIMMYT can efficiently promote and operate? What are the best means for consultations among cooperators? Are the international testing programs of manageable size in terms of data processing and evaluation?
18. Are the program and facilities for training and communications at CIMMYT appropriate and adequate for the present needs of the collaborating countries? How can the needs of African, Asian and Latin American countries be best accommodated?
19. Are the various service facilities, particularly in documentation and computing, adequate for the requirements of an institute of CIMMYT's current size?

Additional Questions proposed by the Program Committee of CIMMYT  
(March 1982)

1. How valid is the medium-term plan presented in "CIMMYT Looks Ahead" in the circumstances observed two years later?
2. How might the role and priorities of CIMMYT be modified in the context of the expected strengthening of national agricultural research capacity?
3. Will CIMMYT's off-campus responsibilities and programs be significantly affected by the operations of ISNAR, now in its second year of active existence?
4. Should CIMMYT re-orient its programs and deployment of resources to give greater proportionate attention to its mandate crops in Africa, as opposed to Asia and Latin America?
5. How does the role exercised by the Board of Trustees and its Committees, and their relationship with the Directorate and the CGIAR system, correspond with the recommendations and observations of the CGIAR Review Committee?

PROGRAM AND ITINERARY OF THE PANEL

Saturday, 4/Sunday, 5 September

- Panel members arrive at CIMMYT

Sunday, 5 September

- P.M. - General presentation of CIMMYT (slides)
- Closed organizing session of the Panel
- Panel meets international staff, post-doctoral fellows, visiting scientists, associate scientists, heads of support units at guesthouse

Monday, 6 September

- A.M. - General opening session, formal introduction of the Panel to the staff and vice-versa, aims and objectives of the review
- Implementation of recommendations of last quinquennial review
- Progress and problems during last quinquennium
- P.M. - Future program and strategy of CIMMYT
- Priorities and resource allocation
- Alternative strategies
- Training concept and philosophy
- On-farm research - concepts and philosophy
- Evening closed session of the Panel

Tuesday, 7 September

- A.M. - Review of the Wheat Program - general introduction followed by visits to germplasm bank, laboratories and experimental fields at El Batan
- P.M. - Presentation of an analysis of CIMMYT's wheat trial data in the Auditorium
- Panel meeting with the Wheat Program Leader
- Panel closed session

Wednesday, 8 September

- A.M. - Visit to wheat field crops at Toluca (including bread wheat, durum, barley, triticale, barley pathology, agronomy)
- P.M. - Round-table discussion of the Panel with the Wheat Program staff
- Return to El Batán
- Closed session of the Panel with the Deputy Director-General

Thursday, 9 September

- A.M. - Presentation of the Regional Programs, national projects and future related activities
- P.M. - Closed session of the Panel
- Wrap-up discussion with the Wheat Program staff

Friday, 10 September

- A.M. - Presentation and discussion of the Economics Program
- P.M. - Review of support services (station management, laboratories, data processing and communications)

Saturday, 11 September <sup>1/</sup>

- A.M. - Review of administration, including budgeting, financial management and personnel
- Review of relationships between CIMMYT and Mexico (closed session with senior Mexican staff members)
- P.M. - Afternoon free
- After dinner discussion in closed session with the Director-General

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<sup>1/</sup> Two Panel members, Drs. Hall and Popow, visited the maize program at Tlatizapan Station.

Sunday, 12 September

A.M. - Free

P.M. - Lunch at the Deputy Director-General's home with Directing Staff

Monday, 13 September

A.M. - Departure for Poza Rica Station  
- Presentation of the Maize Program

P.M. - Presentation of the Maize Program (continued) and discussion

Tuesday, 14 September

A.M. - Presentation of maize production training at an on-farm re-  
search site including economics aspects  
- Return to Poza Rica Station for general discussion

P.M. - Return from Poza Rica to El Batan

Wednesday, 15 September

A.M. - Presentation of the Maize Program (continued)  
- International testing - wide crosses - regional programs and  
national programs (Central American and Caribbean, Mexico,  
Tanzania)

P.M. - Closed session of the Panel on the Maize Program  
- Wrap-up session with the Maize Program

Note: The Panel then split into two groups until Saturday, 18 September p.m.

Group A departed for Guatemala (Drs. Robinson, Plucknett, Popow,  
Parlevliet)

Group B (Drs. Dillon, Hall, Qualset, Mahler, Wangati) stayed in  
Mexico.

Thursday, 16 September

- Group A      A.M.   - Visit with ICTA authorities in Guatemala City  
                             - Presentation of the Maize Program  
                             - Departure for Asuncion Mita
- P.M.   - Visit seed production plots at Asuncion Mita  
                             - Visit small farmer commercial maize producers
- Group B      A.M.   - Visit wheat on-farm research trials and training  
                             activities in Tlaxcala region
- P.M.   - Lunch with a farmer at Zoltepec  
                             - Return to El Batan  
                             - Evening discussion with the Head of the Economics  
                             Program

Friday, 17 September

- Group A      A.M.   - Departure from Guatemala City for San Jeronimo ICTA  
                             Experimental Station - CIMMYT international trials -  
                             High quality maize protein trials in farmers' fields  
                             and agronomy trials in San Jeronimo and Salama Valley
- P.M.   - Return to Guatemala City - Dinner with Ministry of  
                             Agriculture authorities
- Group B      A.M.   - Report writing
- P.M.   - Report writing

Saturday, 18 September

- Group A      A.M.   - Return to Mexico
- Group B      A.M.   - Report writing

Sunday, 19 September

- Report writing
- After dinner discussion with the Head of the Maize Program

Monday, 20 September

- Report writing and Panel discussion

Tuesday, 21 September

- Report writing and Panel discussion

Wednesday, 22 September

- A.M. - Report writing and Panel discussion
- P.M. - Panel meeting with the Board of Trustees

Thursday, 23 September

- A.M. - Panel's discussion with the Board of Trustees on the draft report
- P.M. - Panel's discussion with the Board of Trustees (cont'd) and then with the Board and Directing Staff, on the draft report

Friday, 24 September

- A.M. - Finalization of the draft report
- P.M. - Presentation of the Panel's conclusions to CIMMYT's Board of Trustees, Directorate and staff

Saturday, 25 September

- Panel departs from Mexico

LIST OF DOCUMENTS 1/

(Briefing Documents for the Review Panel)

A. Documents provided by CIMMYT

"Establishing Program Priorities at CIMMYT", prepared for the 1982 Quinquennial Review Team, August 31, 1982.

"The Optimum Size of CIMMYT", prepared for the 1982 Quinquennial Review Team, August 31, 1982.

"Briefing Book - 1982 Quinquennial Review International Maize and Wheat Improvement Center (CIMMYT), August 1, 1982.

"Review of 1976 Quinquennial Review Conclusions/Recommendations", by R.D. Osler, 4 September 1982.

"CIMMYT Collaborative Research Activities (Present Work and Future Needs)", September 1982.

"CIMMYT Today No. 9 - CIMMYT Training", October 1978.

"CIMMYT Today No. 10 - International Testing Program in Wheat, Triticale and Barley", July 1979.

"CIMMYT Today No. 14 - Guatemala's National Maize Program", August 1981.

"CIMMYT Review 1981".

"CIMMYT Review 1982".

"CIMMYT Biennial Budget Request for 1983-1984".

"CIMMYT Looks Ahead - A Planning Report for the 1980s".

"World Wheat Facts and Trends", 1981

"World Maize Facts and Trends", 1982.

"CIMMYT Report on Wheat Improvement - 1979", 1981.

"Planning Technologies Appropriate to Farmers - Concepts and Procedures", Economics Program CIMMYT, 1980.

"Instructions for the Management and Reporting of Results for Wheat Program International Yield and Screening Nurseries"

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1/ Only the major documents are listed here. The Panel had received many additional working papers, publications and other documents from CIMMYT and its cooperators during the review.



- "Triticale - Progress and Promise".
- "CIMMYT Report on Maize Improvement, 1978-79", 1981.
- "CIMMYT Maize Training - Off Stations Experiments 1982 B".
- "CIMMYT's Maize Program: An Overview", 1982.
- "Improving Maize Production in Latin America", by E.W. Sprague, Director Maize Program, CIMMYT.
- "Four Years of Maize Research in Guatemala, 1976-1980 - Final Report".
- "Maize in North Veracruz State, Mexico - Farmer Practice and Research Opportunities", by L. Harrington, Q. Alam, I.A. Rop, I. Basa, P. Rodvinij, P. Tulachan.
- "CIMMYT's Maize Germplasm Improvement and Utilization Program", by S.K. Vasal, A. Ortega C., and S. Pandey, (Draft).
- "Improved Yield and Yield Efficiency of Tropical Maize: A Morphological Basis for Selection", by K.S. Fisher, E.C. Johnson, G.O. Edmeades, and A.F.E. Palmer, (Draft).
- "From Agronomic Data to Farmer Recommendations - An Economics Training Manual", by R.K. Perrin, D.L. Winkelmann, E.R. Moscardi J.R. Anderson, 1979.
- "Maintenance and Seed Production of Open-Pollinated Maize Varieties in Developing Countries", First Working Draft, CIMMYT.
- "Research and Technology Transfer", by A.D. Violić, F. Kocher and A.F.E. Palmer.
- "Relationship between research and extension services and the mutuality of their interests in agricultural development", by A.F.E. Palmer, A.D. Violić, F. Kocher.
- "Feeding Mankind in the 1980s: The Role of International Agricultural Research", by N.E. Borlaug, January 5, 1982.

B. Other Documentation

- "Report of the UNDP Consultant Mission to Review Research and Training in the Development of Quality Protein Maize, Phase III (GLO/75/007) at the CIMMYT, 12-15 June 1978", UNDP.
- "Assessing Farmers' Needs in Designing Agricultural Technology - by CIMMYT Economics Staff", IADS Occasional Paper, 1981.
- "Analysis of Cooperation and Coordination between the International Research Centres (CIMMYT, CIAT, CIP) and the National Centers of Latin America", the Report of a Project conducted by Iowa State University for the Inter-American Development Bank Project No. ATN/TF-1798-RE(4).

LIST OF TRIP REPORTS BY PANEL MEMBERS 1/

- 1) "CIMMYT Quinquennial Review Report on Visit to Thailand", by Drs. C.O. Qualset and J.L. Dillon.
- 2) "CIMMYT Quinquennial Review Report on Visit to Bangladesh", by Drs. C.O. Qualset and J.L. Dillon.
- 3) CIMMYT Quinquennial Review Report on Visit to Pakistan", by Drs. C.O. Qualset and J.L. Dillon.
- 4) "CIMMYT Quinquennial Review Report on Visit to Turkey", by Dr. C.O. Qualset.
- 5) "Quinquennial Review of CIMMYT - Report on Visit to Ecuador", by Drs. H.F. Robinson, A.E. Hall and Messrs. G. Popow and P.J. Mahler.
- 6) "CIMMYT Quinquennial Review 1982 - Report of Review of the International Winter x Spring Wheat Program at Oregon State University", by Drs. C.O. Qualset, A.E. Hall and Mr. P.J. Mahler.
- 7) "CIMMYT Quinquennial Review Report on Visit to Kenya", by Dr. J.L. Dillon.
- 8) "CIMMYT Quinquennial Review Report on Visit to Ghana", by Dr. F.J. Wangati, Mr. G. Popow and Dr. J.L. Dillon.
- 9) "CIMMYT Quinquennial Review Report on Visit to IITA, Nigeria", by Mr. G. Popow, Drs. F.J. Wangati and J.L. Dillon.
- 10) "Visit to ICARDA, Aleppo (Syria)", by Mr. G. Popow.

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1/ These reports related to the visit of off-campus activities of CIMMYT by members of the Panel as indicated in Chapter A. The reports were used as inputs in the discussions of the Panel. The findings and recommendations of these reports are the responsibility of their authors, in their personal capacity and do not commit the Panel as a whole, CIMMYT or TAC, or the national institutions concerned. These reports are available to the members of TAC and CGIAR on request, with the concurrence of CIMMYT.

THE OPTIMUM SIZE OF CIMMYT <sup>1/</sup>

(as stated by the Center)

The terms of reference provided by TAC to the Quinquennial Review Panel instructs the Panel to consider the optimum present and future size of CIMMYT (para. 11-d).

The concept of optimum size is intellectually appealing but operationally difficult to specify. To even attempt such an exercise, the concept of ideal size of a particular center within the CGIAR family of institutions must somehow incorporate judgemental assessments on:

1. The scope, nature and importance of the problems being addressed by the target organization.
2. The time frame required (or tolerable) to solve, or at least ameliorate, the specified problems being addressed.
3. An assessment of the role and efficiency of other organizations pursuing similar broad objectives and a judgement about potential returns from investments in those institutions.
4. For specific problems the comparative advantage of the target organization vis-à-vis other institutions at the time and over time.
5. The likely benefits, in terms of increased efficiency, cost-effectiveness and accelerated timeliness, from marginal additional resources directed toward solving the problem(s).
6. An estimate of the minimum critical mass of human, physical and financial resources necessary to address the problems in a non-trivial manner.
7. The size of the overall budget from which the organization draws its funds.

To have any realism, these judgements must then be ranked and juxtaposed against alternative funding scenarios.

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<sup>1/</sup> Originally prepared by CIMMYT for the 1982 Quinquennial Review Team and subsequently the text was revised by CIMMYT, October 1, 1982.

This question of the appropriate size of the CGIAR System and its individual components has been frequently considered but not resolved by the donor community. The First Review of the System cautioned that the individual centers should not become so large as to become unwieldy (Pages 86-87). The Second Review of the System established the permanent nature of the IARCs, but left open the question of ultimate size of the centers and the System. This Second Review report, endorsed by the donors (when discussing incremental growth for established institutes), states (in para. 10.9, page 122) that "In this connection, the Committee does not favor the concept of a predetermined optimum size for any particular institution. Rather, the institutions should expand, contract, or change their methods of operation according to the needs of the work and the resources available." The five year plan recommended by the Review Committee included limited funds designated to cover "Estimated increases to bring all existing institutions to an approved level and standard of operation" (item a-2, page 124).

In its interpretation of donor attitudes, the CGIAR Secretariat has frequently stated that there is a donor consensus, which assumes that the older, more established centers are fully developed and require virtually no further real growth. Somehow, the Secretariat staff has persisted in the notion that the "optimal" size of the established centers just happened miraculously to coincide with the period when real growth in the System became difficult. CIMMYT's Trustees and management reject this convenient conclusion.

To date, CIMMYT has never been asked by the System to present its final "optimum-size model". When CIMMYT's 1980-86 planning document was prepared and approved, a three percent per annum real growth rate in the established centers was considered reasonable, and indeed, desirable. The staff development plan presented in CIMMYT Looks Ahead - A Planning Report for the 1980s was based on these potential future funding flows, as well as an assessment of the current resource base and priority rankings of research in progress. CIMMYT Trustees and management considered that this staff development plan offered a high marginal rate of return compared to other investment opportunities in agricultural research available to donors.

Since the development of the 1980-86 plan, funding levels have fallen considerably short of the optimum-size plan for CIMMYT in the 1980s. Faced with the cutbacks in funds, highly desirable staffing plans have been modified to the point of representing disinvestments in some previously initiated program thrusts. We remain convinced that some of the understaffing implicit in the 1983 manpower levels should not occur. Attached is a modified, short-term staffing plan for CIMMYT's international scientists designed to restore a relatively few number of key positions beginning in 1983 that are not currently in the 1983 "TAC-Recommended"

Budget Proposal. These positions are shown under the column headed "Mini-Opt". CIMMYT believes that the restoration of these positions would result in a very high rate of return. It would provide for a minimum number of regional scientists in each region where wheat and maize are important crops, plus enhanced back-up in selected critical skill areas at headquarters.

This "Mini-Opt" staffing pattern is consistent with CIMMYT's original 1980-86 plan as well as with the "Supplemental List" provided in the 1983-84 Biennial Budget Request. It also could accommodate each of the positions identified in Chapter I of the Quinquennial Review Report as priority manpower recommendations for future CIMMYT staffing. In fact, five of the six recommended positions are provided for in the minimum/optimum model.

# INTERNATIONAL STAFF POSITIONS

(Man Years)

	(1) 1980 Approved Budget	(2) CIMMYT Long-Range Plan	(3) 1983 TAC Recommended	(4) Mini-Opt. Model	Difference over 1983 TAC Recom.
WHEAT PROGRAM					
Headquarters					
Bread Wheat	2.0	2.0	1.0	2.0	+1
Durum Wheat	1.5	1.0	1.0	1.0	
Barley	1.0	1.0	1.0	1.0	
Triticale	2.0	1.0	1.0	1.0	
Research and Mgmt. Support					
Office of Director	2.0	2.0	2.0	2.0	
Collaborative Research	-	1.0	-	1.0	+1
Germplasm Development	1.0	1.0	1.0	1.0	
Germplasm Bank	-	1.0	1.0	1.0	
International Nurseries	1.0	1.0	1.0	1.0	
Agronomy	2.5	2.0	2.0	2.0	
Pathology	3.0	3.0	3.0	3.0	
Wide Crosses	2.0	1.0	1.0	1.0	
SUB-TOTAL: Headquarters	18.0	17.0	15.0	17.0	+2
Regional Programs					
Latin America Region 1 (Andean)	1.0	3.0	2.0	2.0	
Latin America Region 2 (So.Cone)	2.0	4.0	2.0	2.0	
East Africa	1.0	3.0	1.0	1.0	
North and West Africa	1.0	3.0	2.0	2.0	
South and Southeast Asia	-	3.0	1.0	2.0	+1
ICARDA	0.5	1.0	1.0	1.0	
Disease Surveillance	2.0	1.0	-	1.0	+1
SUB-TOTAL: Regional Programs	7.5	18.0	9.0	11.0	+2
Training	3.0	3.0	3.0	3.0	
TOTAL WHEAT	28.5	38.0	27.0	31.0	+4

	(1) 1980 Approved Budget	(2) CIMMYT Long-Range Plan	(3) 1983 TAC Recommended	(4) Mini-Opt. Model	Difference over 1983 TAC Recom.
MAIZE PROGRAM					
Headquarters					
Improvement					
Breeding	7.5	6.0	5.0	6.0	+1
Plant Protection	2.0	2.0	2.0	2.0	
Physiology/Agronomy	1.0	1.0	-	1.0	+1
Collaborative Research	1.0	1.0	1.0	1.0	
Research and Mgmt. Support					
Office of Director	2.0	2.0	2.0	2.0	
International Nurseries	1.0	1.0	1.0	1.0	
Wide Crosses	1.0	2.0	1.0	1.0	
SUB-TOTAL: Headquarters	15.5	15.0	12.0	14.0	+2
Regional Programs					
Latin America Region 1 (Andean)	3.0	3.0	3.0	3.0	
Latin America Region 2 (So.Cone)	-	2.0	-	-	
Central America/Mexico/Caribbean	2.0	2.0	3.0	3.0	
East Africa	-	2.0	1.0	2.0	+1
West Africa	0.5	2.0	2.0	2.0	
Asia	1.0	2.0	1.0	2.0	+1
Middle East	1.0	1.0	1.0	1.0	
SUB-TOTAL: Regional Programs	7.5	14.0	11.0	13.0	+2
Training	3.0	3.0	3.0	3.0	
TOTAL MAIZE	26.0	32.0	26.0	30.0	+4

	(1) 1980 Approved Budget	(2) CIMMYT Long-Range Plan	(3) 1983 TAC Recommended	(4) Mini-Opt. Model	Difference over 1983 TAC Recom.
ECONOMICS PROGRAM					
Headquarters					
Research and Mgmt. Support	2.0	3.0	2.0	2.0	0
Regional Programs					
Andean	1.0	-	1.0	-	
Central America/Caribbean	1.0	1.0	1.0	1.0	
East Africa	1.0	1.0	1.0	1.0	
Southern Africa	-	-	-	-	
Asia	1.0	2.0	1.0	2.0	
North and West Africa	-	1.0	-	-	
SUB-TOTAL: Regional Programs	4.0	5.0	4.0	4.0	0
Training	1.0	1.0	1.0	1.0	
TOTAL ECONOMICS	7.0	9.0	7.0	7.0	0
RESEARCH SUPPORT					
Headquarters					
Laboratory Services	2.0	3.0	3.0	3.0	
Experiment Stations	2.0	2.0	2.0	2.0	
Data Processing	1.5	1.0	1.0	1.0	
SUB-TOTAL: Headquarters	5.5	6.0	6.0	6.0	
Training					
Experiment Stations	1.0	1.0	1.0	1.0	
TOTAL RESEARCH SUPPORT	6.5	7.0	7.0	7.0	0



	(1) 1980 Approved Budget	(2) CIMMYT Long Range Plan	(3) 1983 TAC Recommended	(4) Mini-Opt. Model	Difference over 1983 TAC Recom.
INFORMATION SERVICES					
Headquarters					
Publications	4.0	5.0	4.0	4.0	0
GENERAL ADMINISTRATION					
Headquarters					
Office of Director General	4.0	4.0	4.0	4.0	
Financial Management	1.0	2.0	1.0	1.0	
Administrative Services	1.0	1.0	1.0	1.0	
TOTAL GENERAL ADMINISTRATION	6.0	7.0	6.0	6.0	0
SUB-TOTAL: HEADQUARTERS	51.0	53.0	45.0	50.0	+5
SUB-TOTAL: REGIONAL PROGRAMS	19.0	37.0	24.0	27.0	+3
SUB-TOTAL: TRAINING	8.0	8.0	8.0	8.0	0
GRAND TOTAL	78.0	98.0	77.0	85.0	+8

