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PROGRAMME PLANNING

COUNTRY, INTERCOUNTRY AND GLOBAL PROGRAMMES

Assistance for a global project

Research on Development of New Stress-Resistant Maize Genetic Resources - Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) (GLO/90/003)

Recommendation of the Administrator

Estimated UNDP contribution: $6,809,000

Duration: Five years

Executing agency: UNDP in association with World Bank and FAO

I. BACKGROUND

1. The Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) is an autonomous international, non-profit, scientific research and training institution. From its headquarters in Mexico and from offices at a number of other locations around the developing world, the Centre operates a global programme for improvement of maize, wheat and triticale (a cross between wheat and rye), investigates economic issues related to these crops, and provides various forms of support to about 100 national agricultural research programmes responsible for maize and wheat in developing countries.

2. The Centre provides its clients with five primary products and services:

(a) Improved maize and wheat germ-plasm for major production environments in the developing world;

(b) Efficient methods for plant breeding, crop improvement research, and agricultural decision-making, especially in research;

(c) Training of various types;

(d) Scientific information stemming from the Centre's own research and from the work of others;

(e) Consulting services (technical consultation and assistance).

3. Continuing high population growth, negative trends in cereals production, and steady deterioration of the natural resources upon which this production is based have made sustained agriculture the most pressing issue in agricultural research for the developing world. The challenge, according to the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR), is to achieve "successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources".

4. Significant increases in the maize production of developing countries have been brought about in large part through the development and wide dissemination of new genetic resources and accompanying improved crop management practices. Through a similar combination of technologies, much can be done to help sustain current rates of productivity growth into the next century. A major obstacle to achieving this goal is the lack of stress-resistant germ-plasm, which, if available and widely disseminated, would permit more efficient use of natural resources (and hence their conservation) and help reduce excessive application of potentially harmful chemical inputs. The principal uncontrolled biotic stresses in developing countries are damage caused by various species of stem borers, along with fall army-worm, and the most challenging abiotic stresses are drought, nitrogen deficiency, and aluminium toxicity in acid soils.

5. Sustaining natural resources is 1 of 12 interrelated criteria presented by CIMMYT's strategic plan as a means of assigning priorities to research activities. The plan, which was approved by TAC late in 1988, also endorses the research strategy outlined in this project proposal for generating germ-plasm that will provide maize researchers in developing countries with readily usable sources of stress resistance.

6. CIMMYT's entire strategic plan and research strategy for developing sources of stress resistance draw heavily upon inputs from researchers and administrators in national research programmes. The growing demand for stress-resistant germ-plasm in developing countries (a demand to which this project responds) is a sign of concern about the stability and sustainability of maize production.

7. The immediate beneficiaries of the project will be national agricultural research programmes requesting "source germ-plasm", which comprises combinations of

genes conferring resistance to one or a few critical stresses. In addition to obtaining this powerful tool for improving their contributions to farmers, maize researchers in developing countries will receive a wealth of practical and basic knowledge about the germ-plasm itself and about techniques for improving it. For areas where the source materials are not well adapted, their task will then be to incorporate the source germ-plasm into locally adapted élite germ-plasm to develop final products for release to farmers. The ultimate beneficiaries of the project would be people of developing countries who consume maize directly or indirectly.

8. The major achievement of the maize programme in the past 15 years has been to generate and distribute a wide array of broadly adapted, normal quality protein maize (QPM) germ-plasm for most of the major maize production areas of the developing world. Through research supported by the United Nations Development Programme (UNDP) from the early 1970s to the mid-1980s, the QPM materials were offered to national programmes after the resolution of complex problems with the original opaque-2 germ-plasm. This experience has shown that a well-supported and focused project staffed by plant breeders and other specialists can overcome apparently insurmountable technical barriers.

9. In the past five years, UNDP has supported international testing of improved germ-plasm. An important outcome of this work (apart from gains in the efficiency of production resulting from adoption of varieties and hybrids derived from the Centre's germ-plasm) is that many national maize research programmes have steadily strengthened their research capacity through further improvement of germ-plasm obtained from CIMMYT and through the Centre's training (also supported by UNDP) and other support services. Some programmes, particularly those in Brazil, China, Ecuador, Egypt, Guatemala, India, Kenya, Mexico, the Philippines, Thailand, Turkey and Zimbabwe, are now prepared to embark on technically demanding programmes for incorporating sources of stress resistance into their own élite, locally adapted germ-plasm. The greater skill and experience of researchers in these programmes account in part for their growing interest in receiving this new class of material to try to overcome these production constraints which continue to be impediments.

10. Another source of encouragement for the project proposed here is recent developments at the Centre in research on resistance to stem borers and fall army-worm and tolerance to drought and aluminium toxicity. Innovative entomology research has produced efficient techniques for developing multiple insect-resistant populations. The development of these and additional special purpose populations, as they are termed, has become the central activity of CIMMYT's maize entomology unit. Maize programme physiologists have also met with success in developing five strains that already show high tolerance to drought. In addition, various populations and varieties with tolerance to aluminium toxicity are being developed, improved and distributed internationally for preliminary testing by CIMMYT breeders based in Colombia at the headquarters of the International Centre for Tropical Agriculture (CIAT). Just as important, if not more so than the germ-plasm emerging out of this work, are the insights and techniques derived from it that will permit CIMMYT staff and scientists in national programmes to generate additional sources of resistance.

11. The development of initial sources of stress resistance (in the form of special purpose populations) has proved to be time-consuming and expensive, because of the difficulty of selecting for complex traits. However, new techniques emerging from research in molecular biology, particularly the application of molecular markers, show promise for helping CIMMYT to develop these populations with increased speed, precision and cost-effectiveness over the next 5 to 10 years. At the end of that period, it is expected that readily usable sources of resistance will be in the hands of selected national programmes and that they will be well informed and equipped for handling these materials. They will therefore be able to incorporate resistances into locally adapted germ-plasm.

II. THE PROJECT

12. The primary objective of the project will be to identify and improve for the principal maize production environments of the developing world a wide range of germ-plasm complexes, each of which shows high levels of resistance or tolerance to one or more of the following stresses: stem borers and fall army-worm, drought, low nitrogen levels, and aluminium toxicity in acid soils. Opportunities are seen for advancing this work through the use of molecular markers, mainly in screening germ-plasm for insect resistance and tolerance to drought.

13. More specifically, the project will:

(a) Evaluate possible sources of resistance, including landraces as well as improved maize from around the world, containing biochemical and biophysical resistance or tolerance mechanisms into a population showing good overall agronomic performance; and screen the population for resistance to a pest complex consisting of three stem borers (the species that can be handled in Mexico);

(b) Evaluate agronomic traits such as grain yield, ear length, etc. of maize materials in combination with sources of resistance in various forms in an effort to develop varieties and hybrids;

(c) Evaluate the source materials for resistance to fall army-worm and six stem borer species (the most important ones world-wide) in co-operation with selected national programmes;

(d) Continue promotional work on quality protein maize and its adoption in selected developing countries.

14. The programme of developing germ-plasm tolerant to aluminium toxicity will be conducted through CIAT in Colombia in close co-operation with the national maize programme in Brazil.

15. The project will also try to identify and employ molecular markers for locating genetic segments in maize and tripsacum (a wild relative of maize) that are associated with insect resistance and drought tolerance. This exploratory work will initially be done in co-operation with other national research institutions that possess special competence in molecular biology. CIMMYT has already taken

steps to acquire the capacity to employ molecular markers in the development of stress-resistant germ-plasm. The construction of a biotechnology laboratory complex is nearly complete, staff have been appointed, and CIMMYT has become involved in several projects involving the use of molecular markers. One is a pilot project conducted in co-operation with Mexico's Centre for Research and Advanced Studies (CINVESTAV) designed to enhance yield potential and stability. Another joint project with CINVESTAV is using modern biotechnology techniques to identify genetic segments associated with drought tolerance.

16. The project will establish a system for screening and improving germ-plasm in co-operation with selected developing country maize programmes which will be the primary mechanism for channelling resistant germ-plasm, techniques and information into national programmes. It will also be essential for achieving the other objectives of the project, since information supplied by national programme co-operators on the performance of the germ-plasm is a critical requirement for its further improvement.

17. Finally, the project will work to improve the capacity of national programmes to develop stress-resistant germ-plasm by offering associate scientist positions and visiting scientists' fellowships to outstanding candidates in developing countries. Participants will spend from a few weeks to one year at CIMMYT headquarters, working with project staff on specific aspects of the research with stress-resistant germ-plasm.

18. The global exchange, evaluation and utilization of improved varieties and breeding material would benefit national programmes of several maize-growing countries in Asia, Africa, Latin America and the Caribbean. Improved varieties for unfavourable conditions will greatly benefit the small farmers growing maize in marginal areas. Varietal resistance to biotic and abiotic stresses would, on the one hand, reduce the production costs and, on the other hand, provide a measure of stability to production.

19. The project will be an integral part of the international co-operative programmes of CIMMYT, which are being supported by the CGIAR donor group. CIMMYT thus provides the necessary physical facilities for the execution of the project. The project network links the various national programmes concerned with maize improvement for implementation of the plans. The participating countries for CIMMYT contribute improved varieties and breeding lines to the testing pool and also conduct the trials and exchange the result for mutual benefit. Selected countries offer "hot spot" screening facilities for different stresses under which maize is grown. Any genetic material and technology developed under this project and found promising for the growing conditions in any country would be freely available to all national agricultural research systems for use by farmers in that country by simply acknowledging its origin.

20. UNDP will provide 60 man-months each of a breeder, an entomologist and a physiologist plus junior scientific staff, operational costs and funds for collaborative research with selected national agricultural research systems. Specific components of biotechnology research will be carried out jointly with

selected national programmes. Appropriate sums from the total UNDP funds allocated to the project will be used for this purpose.

21. The Administrator intends, through contractual arrangements between CIMMYT and UNDP, to entrust the implementation of this project to CIMMYT with the clear understanding that the Directorate of CIMMYT will seek the advice of the Food and Agriculture Organization of the United Nations (FAO). As in the past, UNDP will follow closely all the developments in this global project and, together with FAO, will participate in the project advisory committee which will be established for the project. A concerted effort will be made for linking the research activities to be undertaken with field-work being carried out at the country and intercountry levels. The project advisory committee, which will oversee this co-ordination, will include renowned scientists currently engaged in all relevant aspects of maize breeding, genetics, testing and biotechnology research. The committee normally will meet once a year to appraise ongoing research activities and to advise on its future direction. Specialists from other international centres will be invited, as appropriate, to serve on this committee.

22. Midway in the course of the project, UNDP, in consultation with CIMMYT, might decide to schedule an evaluation of the project activities to be undertaken by a team of two or three independent consultants. Such an evaluation could be undertaken in conjunction with one of the project advisory committee meetings mentioned in paragraph 21 above. The findings and recommendations of the mid-project evaluation might necessitate the reorientation or modification of project goals, budget and work plans for the remainder of the project. Towards the completion of the project, a thorough evaluation of its results and accomplishments will be mounted by UNDP, in consultation with CIMMYT, to be carried out by independent and prestigious consultants.

23. The proposed UNDP contribution is $6,809,000 of which $6,609,000 will be for sub-contracts, while direct costs will account for the remaining $200,000. The expenditures under the project through 1991 will be contained within the indicative planning figure (IPF) for global projects established by the Governing Council for the fourth cycle. The expenditures covering the remaining period of the project will be subject to approval of the fifth cycle IPF commencing 1 January 1992.

III. RECOMMENDATION OF THE ADMINISTRATOR

24. The Administrator recommends that the Governing Council approve this project.
