AGPP:Misc/73/7
April 1973

F.A.O. PROJECT FOR WORLDWIDE COORDINATED RESEARCH ON HORIZONTAL RESISTANCE TO WHEAT DISEASES

1. Title: The Investigation and Development of Horizontal Resistance to Important Wheat Diseases.

2. Duration: Five years plus five years.

3. Introduction:

In the past, plant breeding for disease resistance has of necessity been constricted by the techniques available to plant breeders. In particular, 'vertical' resistance[1] has been favoured. Because vertical resistance is inherited by major genes, it is easy to manipulate genetically. However, its effectiveness is liable to break down due to a change in the pathogen. Its use generally leads to an unending cycle of breeding new cultivars to replace those whose resistance has been lost.

In contrast, horizontal resistance is stable resistance. However, it is usually inherited by minor genes and is difficult to manipulate in a breeding programme. Its utilisation, especially in self-pollinated crops such as wheat, rice, barley, oats and flax, requires a new and unconventional approach to plant breeding.

This is a particularly acute, second-phase problem in the wheats of the Green Revolution. The makers of the Green Revolution produced this major achievement in the minimum time by using the tools available. Disease resistance was inevitably based on vertical resistance and, however many cultivars are now involved, there are still relatively few vertical resistances available. The Green Revolution now possesses three factors for instability. The first is the vertical resistance which is liable to fail. The second is the relatively large area of crop

(1) J.E. van der Plank, (1968) "Disease Resistance in Plants", Academic Press.

dependant on any one vertical resistance. The third factor is the difficulty of large-scale cultivar replacement in developing countries which lack both the plant breeding facilities and the seed multiplication and distribution machinery.

The project is designed to produce a wide range of new cultivars and breeders' material of wheat possessing horizontal resistance to the major wheat diseases. Our knowledge of horizontal resistance is now adequate to define a comprehensive programme with clear-cut objectives.

4. Objectives:

i) To increase stability in the Green Revolution and wheat cultivation generally by producing new wheat materials with horizontal resistance to all major diseases.

ii) To provide a convincing demonstration of the methods, feasibility and potential value of horizontal resistance in other crops.

5. Justification:

Recommendation No. 8 of Commission I of the 1970 World Food Congress begins: "The new movement in plant breeding is a technical breakthrough which has created world-wide confidence in the possibility of increased production. However, its present fragile basis must be greatly strengthened if a real Green Revolution is to be achieved. It is particularly important that the scientific elimination of factors responsible for instability should be attempted..."

The international scientific community is aware of the gravity of this problem and has made comparable recommendations. The most recent is that of the 1972 European and Mediterranean Cereals Rusts Conference which moved: "plant pathologists develop practical methods for screening varieties possessing non-specific (i.e. horizontal) types of resistance".

6. The Method:

The proposed method is based on an analysis of the factors which governed the natural accumulation of horizontal resistance in African maizes

to Puccinia polysora following the accidental introduction of this pathogen from Central America.[1] Although, in detail, none of the techniques is new, they collectively constitute a new approach to the breeding of self-pollinated annual crops. The important factors are as follows:

Sources of horizontal resistance
Genetic heterogeneity and male sterility
Selection pressure for resistance and other qualities
The time required
Identification and appraisal of new cultivars.

6.1 Sources of horizontal resistance. When P. polysora reached Africa, the local maizes were highly susceptible to it because of the loss of horizontal resistance due to changes of gene frequency in the host populations. High levels of horizontal resistance to P. polysora were re-established in the African maizes after a number of years without the introduction of any foreign parent material. It is considered that the desired gene frequencies can also be restored by breeding within existing wheat cultivars and that a search beyond existing cultivars and, possibly, among wild progenitors is not necessary at this stage.

6.2 Genetic heterogeneity and male sterility. The African maizes exposed to P. polysora were peasant crops grown from the farmers' own seed. They were thus the result of a long-established and continuing random polycross. The present project is based on an imitation of this situation in wheat. Two populations will be maintained, one of which will be male-sterile and used as female parents, and the other will be male-fertile and used solely as a source of pollen. The use of a male gametocide such as "Ethrel" (2-chloroethylphosphonic acid)[2] is intended. The advantages of a male gametocide over either genetic or cytoplasmic male-sterility are that it is easier to use, it can be applied to any cultivar, its effects are not inherited and there are no undesirable, linked characters.

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(1) Robinson, R.A. (1973) Review of Plant Pathology (April issue).

(2) Rowell and Miller (1971) Crop Science, pp. 629-631.

Genetic heterogeneity will be achieved at the onset by the careful choice of parent cultivars to provide a reasonably wide genetic base. This will be followed by a random polycross for several generations under conditions of low disease intensity.

The random polycross will then be continued under conditions of high disease intensity for some 10-15 generations. Both the male and female populations must be genetically heterogeneous and sown from seed of the previous female generation. Susceptible individuals will be killed or prevented from reproducing; less susceptible individuals can be eliminated as desired by a mechanical screening of the grain.

When the necessary gene frequencies for horizontal resistance have been obtained, the random polycross will be discontinued but all selection pressures will be maintained for 5-6 generations until segregation is concluded.

6.3 Selection pressure for horizontal resistance and other qualities.

Perhaps the most notable feature of the African maizes was that horizontal resistance accumulated naturally in farmers' crops. There were no plant breeders, no breeders' plots, no controlled crosses, no measurements of resistance and, above all, no conscious, artificial selections. The resistance screening was done by the pathogen. This situation will be imitated in wheat.

Selection pressure for horizontal resistance can only be effective if all other disease control factors are absent. The most important of these factors is vertical resistance and either the vertical resistance itself, or its effects, must be eliminated during the screening process. With wheat, the most promising approach is an epidemiological elimination of the effects of vertical resistance by ensuring that all the original, parent cultivars are susceptible to a particular pathogen race which is then used exclusively.

The selection pressure for horizontal resistance is initiated each season by mass-inoculation with the appropriate pathogen race. If necessary, it can be artificially sustained by the sowing of susceptible wheats to provide an additional spore load. Only a minimal control of disease intensity is necessary. Epidemiological failure is represented only by a complete host survival (i.e. no selection pressure whatever) or a complete host destruction. The ideal is to provide enough surviving seed to sow both the female and male populations but no more. This will be achieved mainly by a mechanical screening of the grain.

In so far as the African maize farmers kept their best cobs for seed, they demonstrated that a randomly polycrossing population can be subjected to several different selection pressures simultaneously, including those for yield and quality. The African maizes accumulated horizontal resistance to P. polysora while retaining their existing, high levels of horizontal resistance to other pathogens. It is intended that the wheat populations will be screened primarily for horizontal resistance to Puccinia graminis but also for yield, quality and horizontal resistance to all important pathogens in the locality concerned. All such screening will involve mass-selection, using simple mechanical devices and natural epidemics.

6.4 The time requirement. The African maizes accumulated adequate horizontal resistance to P. polysora in 5-7 years in areas of bimodal rainfall and two generations each year. In wheat, at least 20 generations will be required if allowances are made for obtaining the initial genetic heterogeneity and for ending the final segregation. In high altitude tropical areas it may be possible to obtain 3 generations each year. For temperate, spring wheats, it is intended to utilise the alternate summers in the two hemispheres, obtaining two generations each year. No work with winter wheats is envisaged.

6.5 Identification and assessment of new cultivars. It is anticipated that any one screening location will produce some hundreds of potential new cultivars and that the project as a whole will produce some thousands of lines adapted to a very wide range of ecological and epidemiological criteria. These lines will be identified towards the end of the project when the rates of segregation are much reduced. They will then be sent to local research stations throughout the world for assessment and final selection, either as new cultivars or as parent material in local programmes.

7. Organisation

7.1 The crop and diseases involved. Priority will be given to finding horizontal resistance to Puccinia graminis tritici in wheat. However, because the technique permits simultaneous screening for horizontal resistance to several pathogens, all major wheat diseases will be covered, depending on local epidemiological factors at each screening site.

7.2 Participating research stations. It is intended to use some 10-15 sites in the world, with a very strong emphasis on the developing countries. The project will depend on cooperation between FAO and existing research stations already active in breeding for disease resistance. The choice of participating stations will be made by FAO with the over-riding criterion that the work is effectively and competently conducted. Participating stations will receive financial assistance from the project.

7.3 Associated stations. At the discretion of FAO, additional stations may be associated with the project. Such stations will be those which have independently undertaken breeding for horizontal resistance. Association will involve both the exchange of results and information and the attending of meetings. However, no financial assistance is envisaged for associated stations.

7.4 Research resources. The research resources required are modest. To screen one generation of wheat in one locality would require about one hectare (2.4 acres) of land; perhaps 50 professional and 200 technical man-hours; some routine agricultural operations; minor glasshouse and laboratory facilities; some inexpensive equipment and supplies and the general background of an efficient research station.

Nevertheless, it is intended to offer each participating station a total or partial reimbursement of its additional operating costs for cooperating in the project. In general, the smaller stations in the poorer countries will receive most. Occasionally, such reimbursement may involve larger sums for capital equipment.

In particular, it is considered imperative that participating scientists should all meet at intervals not exceeding two years in order to compare their results, experiences and ideas. Some individual travel between paired stations in the two hemispheres will also be necessary. The costs of travel, subsistence, etc. will be met by the project.

7.5 Duration. The project is planned initially for five years. The first and, possibly, second years will be devoted to organisation and preliminary work. This will include confirmatory investigation of techniques, selection of parents, attainment of genetic heterogeneity, elimination of vertical resistance, etc. In year 4, the project will be reviewed to decide on a possible extension for a further

five years. It is expected that, when the project is concluded in year 10, a multiplicity of wheat lines will be available for local research stations throughout the world.

8. The role of FAO

Because the project concerns so many interests and countries, particularly in the developing world, it is essential that it be administered by an independent, international organisation such as FAO. There would be three primary roles as follows:

8.1 Planning. FAO will prepare a detailed plan of work to ensure the required standardisation and sequence of operations. It will extend formal invitations to stations to either participate or associate, and secure agreement to cooperate. It will administer the supporting funds.

8.2 Coordination. FAO will appoint a Project Manager/Coordinator who will assume responsibility for supplying detailed operating techniques and local instruction and demonstration; standardisation of methods as necessary; and distribution of selected lines in full accordance with international and national quarantine regulations. In particular, he will call meetings of participating and associated scientists to ensure maximum exchange of all experience and results. The Coordinator will be given discretion to modify the project in detail provided that the overall objectives and expenditures are retained.

8.3 Evaluation. In collaboration with participating stations, FAO will undertake the technical and economic evaluation of the results of the project. It will publish all details of this evaluation without prejudice, however, to the usual publishing rights of individual scientists.

9. Staff and finance

9.1 Staff. The project will require a Project Manager/Coordinator who will plan, coordinate service and evaluate the project. In general, he will be expected to visit each participating station, at an appropriate season, approximately once each year. Provision should also be made for consultants at appropriate times in the course of the project and its meetings. Secretarial and clerical assistance will be necessary.

9.2 Estimated project's costs (five years)

Personnel Services		
Project Manager/Coordinator	$	138,100
Consultants		30,000
Secretarial/clerical assistance		47,900
Travel		
Project Manager/Coordinator		60,000
Consultants		40,000
Regional meetings		100,000
Global meetings		100,000
Research Supporting Funds		300,000
Miscellaneous		
Reports, etc.		50,000
		866,000
Contingencies (10%)		86,600
		952,600
Project Servicing Costs (14%)		133,360
Grand Total	$	1,085,960

Abstracts of referees' comments on the FAO project proposal for worldwide coordinated research on horizontal resistance to wheat diseases

A first draft of the FAO's project proposal was prepared in December 1972 under the title "The Investigation and Development of Horizontal Resistance to Some Diseases of Major International Importance, with particular reference to the Green Revolution." (AGPP:MISC/7).

This draft was submitted to a number of world authorities in the field of breeding for disease resistance. Their views and comments were specifically requested on the following major points:

1. Need for the project;
2. Scientific validity of the proposal;
3. Feasibility;
4. Adequacy of organization and resources;
5. Suitability of implementation by FAO.

With one exception, all referees responded to FAO's inquiry with many and useful comments. As a result, several amendments and improvements were introduced in the project proposal.

Since it proved impossible to prepare an unbiased summary of all the pros and cons of these comments, it was decided to summarize them by direct quotations, omitting those parts that are either irrelevant or already included in the new project proposal.

Referees' comments are listed in an approximate order of favourable to unfavourable response.

1. Dr. C. Person, F.R.S.C., Professor, The University of British Columbia, Vancouver 8, Canada.

" The proposed research programme is exceptionally well designed and I have no reservations on its likelihood of success. The need for the research cannot be seriously challenged. The proposal is scientifically sound. I was particularly impressed by the evident care and attention to detail which has gone into the planning and preparation of the proposal. As a programme of research, it will be relatively uncomplicated. It would be ideally suited for FAO auspices. "

2. Dr. J.E. Van der Plank, Plant Pathologist, Department of Agricultural Technical Services, Private Bag x134, Pretoria, South Africa.

" I fully endorse Objectives and Justification. I believe a project on horizontal resistance should be started soon. I believe the general principles stated in Methods to be sound but details must inevitably vary with crop and disease. The suggestions in Organisation would make a good start; in detail one could make counter-suggestions galore but a limit must be imposed. "

3. Dr. J.C. Santiago, Plant Pathologist, Increase and Development of Wheat Production, Caixa Postal 351, 99.100 Passo Fundo RS, Brazil. (Member of the Board of the European and Mediterranean Cereal Rust Foundation).

" This (project) is just the type of work that badly was needed in order to stabilize the yields, to keep low the losses caused by some plant parasites, and to avoid the continuous increase of virulence of such parasites as it has happened with the breeding of vertical resistant varieties. Perhaps this project will face some difficulties and meet some reactions, but I have no doubts that in the long run it will be a success and give information that will surpass even the most optimistic expectations." ... "The steps and methodology in the project are, according to my knowledge, the best ones to be used. "

4. Prof. I. Wahl, Head, Division of Mycology and Plant Pathology, Tel Aviv University, Israel.

" This is an excellent research project whose realisation will have a fundamental impact on world agriculture in practice and theory. The idea of imitating...Puccinia polysora is likely to be most rewarding. FAO has the proper scientific teams and connections to direct this venture. "

5. Dr. A.L. Hooker, Professor of Plant Pathology and Genetics, College of Agriculture, University of Illinois, Urbana, Illinois 61801, USA.

" I...recommend that it be approved and funded. Certainly there is a great need for a project of this type. There is a reasonably high expectation that the stated objectives will be achieved. The proposal has scientific validity and practical feasibility. The organisation and resources seem adequate and the project is suitable of implementation by FAO. "

6. Dr. S.H. Ou, Plant Pathologist, The International Rice Research Institute, P.O. Box 583, Manila, Philippines.

" The idea of horizontal resistance has received a great deal of attention and created lots of discussions. However, there has been relatively little research work done on the major diseases of many important crops. The general idea of pursuing this type of resistance in major crop diseases is very desirable and worthy undertaking as your proposal aims to do."..."In short, we think the idea is very good

but problems in executing the project might arise. It may also be suggested that some preliminary work be done in a smaller scale to resolve the possible problems before the large-scale project is launched. "

7. Dr. K.J. Frey, Professor of Plant Breeding, Department of Agronomy, Iowa State University, Ames, Iowa 50010, USA.

" The undertaking and need for this project is especially timely. I think the project should be slanted towards testing the African maize theories on accumulation of horizontal resistance to P. polysora. I believe a mixture of races would be more valuable than a single race. The project is practically feasible but...will take longer than suggested. It is unlikely that any other organisation could carry out such a programme. The project is well-conceived and timely; I question some minor points but, in general, it is good. "

8. Dr. J.C. Zadoks, Senior Lecturer of Phytopathology, Laboratorium voor Fytopathologie, Binnenhaven 9, Wageningen, The Netherlands.

"...the research proposal is interesting, important, not too expensive, and merits to be put into effect. Robinson's paper is an interesting study, well presented and with good internal consistency. There are various objections to the definition and postulated properties of horizontal resistance. Nevertheless, the observations on maize and P. polysora are so impressive that all theoretical objections should be brushed away. Cultivar replacement is one of the major, second-phase problems of the green revolution...of such importance that all possibilities, including unconventional approaches should be tried. The possibility of finding parents of equal vertical susceptibility may be over-estimated. A fair degree of horizontal resistance might give adequate protection in mild years and permit disease forecasting and an economic use of fungicides in severe epidemics. "

9. Dr. F.G.H. Lupton, Plant Breeder, Plant Breeding Institute, Trumpington, Cambridge CB2 2LQ, England.

" We consider this subject (of horizontal resistance) to be a most important one not only for developing countries but for the most advanced agriculture; in fact I think that it would be no exaggeration to say that problems of disease resistance are the most important limiting factors in breeding for improved cereal varieties in Britain." A number of points of disagreement to the proposal are given. " As a general summary, it seems that the project requires considerable further thought before it can be put into practice but that the subject concerned is of extreme importance to all plant breeders and I would be much interested to hear of any further developments. "

10. Dr. E.C. Stakman, Professor Emeritus, Department of Plant Pathology, University of Minnesota, St. Paul, Minnesota 55101, USA.

" My first criticism is that the project is not comprehensive enough. FAO has a major opportunity if not obligation to locate material of...wheat, rice, maize

and sorghum...resistant to heat, drought, etc. Horizontal resistance (to wheat stem rust) has been studied (at Minnesota) for more than 40 years and has been incorporated in wheats. "

11. Dr. Eva Fuchs, Biologische Bundersanstalt, Messeweg 11/12, 33 Braunschweig, Germany.

" I would like to see an analysis of "horizontal resistance" but I doubt both the practical feasibility of such a large-scale project and some of the ideas, simply transferred from other subjects to wheat. "

12. Prof. A. Bozzini, Director, Laboratorio Applicazioni Nucleari in Agricoltura, Centro di Studi Nucleari della Casaccia, C.P. 2400, 00100 Rome, Italy.

" While, as you know, I am strongly favourable to the project, a few comments could be advocated on some scientific aspects. Conservation of agricultural yield and quality may be difficult. "

13. Dr. M.S. Swaminathan, Director General, I.C.A.R., Krishi Shawan Dr., New Delhi-1, India.

" The topic is an important one. I have, however, doubts about the experimental approach...I wonder if you could send me a pre-print of Robinson's paper which may contain the answers to many of my doubts. I am not sure that we need a global project of this kind. "

14. Dr. R.C.F. Macer, Professor of Crop Production, The Edinburgh School of Agriculture, West Mains Road, Edinburgh EH9 3JG, Scotland.

" I am in complete agreement with the comments made on a personal basis by Dr. Johnson (see below). For many years I have been an advocate of more work being done in this field of horizontal resistance. "

15. Dr. R. Johnson, Secretary, European and Mediterranean Cereal Rust Foundation, Plant Breeding Institute, Trumpington, Cambridge CB2 2LQ, England.

a) <u>On a personal basis</u>. " We feel strongly that work on "horizontal" resistance should definitely be encouraged. In this case, however, the programme presented is over-optimistic and somewhat naïve in conception." (A separate enclosure contains many adverse criticisms of detail and is particularly hostile to the quoted paper by Robinson).

b) <u>As Secretary</u> of the Board of the European and Mediterranean Cereal Rust Foundation. " All the members agreed that it was most desirable that work on horizontal resistance to important pathogens should be encouraged. The replies you received directly from myself and from Dr. Zadoks were the most critical views expressed. "

16. Dr. N.E. Borlaug, Director, Wheat Programme, CIMMYT, Calle Londres 40, México 6, D.F., México.

(no reply received)

DDDR:IAR/73/7
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BACKGROUND PAPER ON PESTICIDE RESIDUES RESEARCH

for the January 1973

MEETING OF THE TECHNICAL ADVISORY COMMITTEE
ON INTERNATIONAL AGRICULTURAL RESEARCH

I. Introduction

Following the establishment by UNDP of its category of "global projects" in early 1970, four related proposals for projects in the pesticide field were received, namely:

(a) "Coordinated Research Programme on the Fate and Significance of Pesticide Residues in Food and the Environment (IAEA);

(b) Regional Centres for Research and Training in the Application of Nuclear Techniques to the study of Pesticide Residues and Pollution Problems in Developing Agriculture (IAEA);

(c) "Pesticide Research Coordination Centre"(FAO;)

(d) "Integrated Plant Pest Control Research Centre" (FAO).

While recognizing the importance of the subject of pesticides residues research, the UNDP has a number of reservations towards the proposals made so far and wishes to have the whole question of possible international assistance in the field of pesticides residues research reviewed by the TAC.

II. UNDP Reservations towards Existing FAO and IAEA Proposals

(a) They are basically (and with partial exceptions) rather loose proposals for research funding, without specifying very clearly what research is to be undertaken or where.

(b) The relations among the proposals are not very clear. For example, IAEA has suggested combining (a) and (b), while (c) is also clearly related to (a) and (b) whereas (d) is not directly concerned with pesticide residues as such but with new methods of pest control which would obviate the need to use the broad spectrum and persistent chemical pesticides, which cause the residues.

(c) UNDP is now recommending to the Governing Council, as a global project, a programme of substantial support to the International Centre for Insect Physiology and Ecology (ICIPE) in Nairobi, Kenya, and this would be largely duplicated by the FAO proposal (d).

(d) There is a certain lack of balance in the proposals (a) and (b) which concentrate only on the, admittedly important, nuclear methods of studying pesticides residues without reference to the broad issue.

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(e) The proposals under review would commit the UNDP to a substantial financial contribution totalling $6.6 million over five years. In view of the very limited uncommitted global projects resources over the next five years, UNDP would prefer to enter into a consortium type funding arrangement with other multilateral, bilateral, and private funding agencies in any global projects of this type.

(f) The proposals raise major questions of project management and effective project execution which they do not answer.

(g) UNDP had not wished to become prematurely committed in this field pending the outcome of the Stockholm Conference and the establishment of the Fund and Secretariat of the UN Conference on the Human Environment (UNCHE), and pending also the results of the major USAID study on pest management and its problems, which is now in progress.

III. Agency Positions

UNCHE Recommendation 21 of the Stockholm Conference, reproduced in Appendix I, is the operative recommendation on pesticide residues. It enjoins Governments, FAO, WHO, UNESCO and IAEA to cooperate on integrated pest control on the one hand, and reduction of the harmful effects of agro-chemicals on the other hand. Specifically mentioned in the context of pesticide residues are basic research on ecological effects of pesticides (Man and the Biosphere programme); use of radiation techniques to study the fate of pesticides in the environment; and international guidelines and standards on pesticide use. It is likely that pesticide residues problems of specific economic or public health concern to developing countries would be eligible for UNDP funding while more general problems of world surveillance, etc. might be eligible for funding by UNCHE.

FAO's Activities in the pesticide field may be summarized as:

(a) Regulation and use of pesticides especially by the preparation and publication of FAO specifications covering technical materials and formulations for plant protection products. Specifications for 15 of the most important of these have been published and 50 more are programmed for the future.

(b) Acute toxicological hazards especially during formulation, transport, storage, and use of pesticides. This is covered by a number of FAO/WHO technical data sheets.

(c) Pesticide Residues in human food and animal feed. FAO/WHO have jointly considered 120 pesticides and recommended 250 pesticides residue tolerance levels for adoption under the Code Alimentarius. At the present funding level no more than 150 of the 500 agricultural pesticides can be kept under review and the problem of pesticide residues in animal feed - of increasing international concern in view of animal feed exports from developing countries to western Europe - has yet to be tackled.

(d) Insufficiency of scientific data on certain pesticides. This is closely related to the last point and is the subject of one of FAO's two project proposals. Concern is centered on pesticides no longer protected by patents or having

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specialized and limited market possibilities so that manufacturing companies have no incentive to undertake needed testing.

(e) Pest resistance to pesticides.

(f) Unintended environmental consequences of pesticides. On this subject, FAO has prepared a technically informative monograph submitted as an annex to its background paper.

(g) Development and integration of alternative pest control methods.

(h) Cost and availability of pesticides, especially technical assistance in local formulation of imported technical grade materials into usable agricultural products near the end use point.

WHO Supports FAO on its points (b) (c) and (d) in which areas the two organizations collaborate closely. WHO also stresses the importance of pesticides residue monitoring in air and water.

IAEA Emphasizes the importance of nuclear techniques especially radioactive isotope tracer studies of pathways of pesticides and their breakdown products through the environment. The joint FAO/IAEA division has a current programme of 29 investigations in 18 different countries concerning pesticide residues and similar contaminant problems most of them being investigated under "cost-free" research agreements. It also has a series of one month training courses in Vienna financed under the IAEA/SIDA cooperative programme. The two IAEA project proposals are outgrowths of these two existing programmes.

UNESCO The Man and the Biosphere (MAB) programme includes as proposed Project 9, the "Ecological Assessment of Pest Management and Fertilizer Use on Terrestial and Aquatic Ecosystems," which project includes as a possible field of action, collection and analysis for pesticide residues of soil, water, air and biota samples.

UNIDO Has indicated its willingness to assist, where invited, in advising pesticide manufacturing facilities, including pesticide formulation plants, on environmental hazards resulting from their operation.

ILO FAO and ILO are proceeding jointly on the production of a "Code of Practice in the Use of Pesticides" covering acute hazards in their production and use.

IV. Classification of Pesticide Problems

In effect, the problem of pesticide residues breaks down into the following fields:

(a) Acute hazards arising from the production, storage, transport and use of pesticides;

(b) Pesticide residues in soil, air, water and biota and their unintended ecological consequences;

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(c) Pesticide residues in human food and animal feeds; and

(d) Integrated pest control methods and alternatives to chemical pesticides.

Additionally, the following distinct activities may be distinguished:

(A) Legal and Regulatory, including

(i) Pesticide manufacture - occupational hazards;

(ii) Pesticide marketing - certification, labelling, and quality control;

(iii) Pesticide use - restrictions on use and methods of application;

(iv) Pesticide residue tolerances in food - acceptable daily intakes (expressed in mg. residue intake per kg. body weight) and residue tolerances on specific crops (in parts per million by weight).

(B) Training and Information, including

(i) In safety procedures for farmers and other users of pesticides;

(ii) For scientists and technicians in instrumental techniques of analysis, such as gas chromatography and in research methods such as those involving radioactive tracers.

(C) Surveillance and Research, including

(i) Monitoring of residues in the environment;

(ii) Research on the distribution, metabolism, persistence and final degradation of pesticides;

(iii) Evaluation of hazards, ecological effects, and unintended consequences of the use of pesticides on the basis of the information of (i) and (ii).

(D) Research and Development of new methods of pest control.

V. FAO and IAEA Project Objectives

(a) Pesticide Research Coordination Centre.

This would set up an ad hoc group of experts on pesticides in the environment paralleling the existing ad hoc group of experts on pesticide residues in food and, on the recommendation of these expert groups, subcontract research problems to established research institutes, which would normally be in developed countries.

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The studies would be principally relating to the effect of particular pesticides in food and in the environment with a view to drawing up acceptable daily intakes and residue tolerances on some of the 350 or so pesticides not yet covered by the Codex Alimentarius. In particular, this would include some pesticides of importance to developing countries for which data is not likely to be obtained by existing regulatory bodies or by manufacturers e.g. because patents have expired or there are limited markets in developed countries for the pesticides in question.

Integrated Plant Pest Control Research Centre

This proposal parallels in many ways the ICIPE global project which UNDP is supporting, except that it envisages an existing centre in a developed country coordinating field projects in each of four geographical regions.

Regional Centres for Research and Training in the Application of Nuclear Techniques

Proposes to establish up to five small training and research centres at existing institutes for nuclear research in developing countries. As already noted, this appears to be too one sided in its approach to the problem of training scientists and technicians. Moreover, the proposed approach falls more appropriately into the scope of a series of purely Regional Projects.

Research on Fate and Significance of Pesticide Residues in Food and the Environment

Envisages some twelve small research contracts to developing country centres for research on problems of interest to developing countries. This proposal lists some 20 research topics each with a proposed institute, see Appendix II. While it is a concrete proposal, there is little evidence on which to judge the validity of the problems chosen, especially as compared to possible other problems not chosen because isotope techniques might not be relevant.

VI. Activities Outside of the Scope of the Present Brief.

UNDP suggests that the following types of activity should not be considered by TAC as being within the scope of a UNDP global project in pesticide residues:

(a) Integrated Pest Control.

This raises broader questions as the field is already largely covered by the ICIPE project. Supplementary recommendations e.g. to strengthen ICIPE on the ecology side might be considered, however, particularly as Ecology is recognized by ICIPE in name only at present. In any event there will be a need in future to programme more technical assistance into integrated control approaches which is a question related, though not directly, to pesticides residues research.

(b) Basically Training Programmes.

These are excluded by the terms of reference for global projects which should be research oriented, although training activities may be acceptable as a necessary part of a research project.

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(c) General Surveillance and Base-line Monitoring.

Activities to determine world levels of pesticides residues in air, water, soil and biota without reference to specific development problems will presumably be eligible for financing by UNCHE.

(d) Legal and Regulatory Recommendations.

These are already being handled by FAO, WHO, and ILO committees and expert groups. However, research on the fate and significance of residues in the environment, and on toxicity testing to acquire data on which recommendations may be based would be eligible for consideration in cases where such research activities have a special significance for developing countries.

VII. Activities Within the Scope of the Present Brief.

UNDP suggests that the following types of activity may be considered within the scope of a possible UNDP global project in pesticide residues:

(a) Fate and Significance of Pesticides in the Environment.

Projects, such as those listed in Appendix II, may be considered if they involve problems of potential economic and/or public health significance to developing countries taking account also of export requirements for human foods and animal feeds, with preference for problems which can be tackled by existing institutes in developing countries.

(b) Pesticide Residues in Human Foods and Animal Feeds.

This is closely related to the last topic and the same considerations apply, except that animal feeding trials, (on which recommendations for acceptable daily intakes and residue tolerances on crops might be based), could be included where they involve special problems of importance to developing countries, even though they would probably need to be undertaken in developed country laboratories.

VIII. Questions to be Resolved

Finally, the TAC may wish to make recommendations on the following:

(a) Whether there are problems of pesticide residues in the environment or in food which, taken either individually or collectively, are of high economic and/or public health significance to developing countries, and which might be solved through a global project based in some developing country. In particular, it may wish to consider whether there are research problems appropriate to a global approach concerning the export of agricultural products and ensuring that these exports meet the rigid standards for pesticide residues now being established by the developed countries. UNDP is already supporting national projects of this type in Poland, Egypt, Brazil, and Thailand.

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(b) If there are such significant problems which might justify a UNDP global project, it is then necessary to determine the next steps in its elaboration as a project.

(c) A possible course of action would be to request the IAEA/FAO division to collaborate with FAO and with WHO in the preparation of a detailed project proposal.

This might take the form of a list of identified projects and established laboratories, preferably in developing countries, where each might be executed. The list of Appendix II might be a starting point but other proposed projects could be added including perhaps one or two programmes of toxicity testing. For each research project, it would then be necessary to establish:

(i) Description and objectives;

(ii) Expected economic and health benefits;

(iii) Research methodology which should correspond to the merits of the problem whether it involve nuclear or any other techniques;

(iv) Expected manpower, equipment, and other inputs, duration and timing, and budget requirements;

(v) Proposals for monitoring project;

(vi) Proposals for follow-up actions to ensure effective utilization of research results.

It would further be necessary to identify an established research institute, probably in a developed country, to undertake under sub-contract, management and coordination of the research programme. Finally, an overall project proposal and budget should be prepared.

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APPENDIX I

Recommendation 21

It is recommended that Governments, the Food and Agriculture Organization of the United Nations and the World Health Organization, in co-operation with the United Nations Educational, Scientific and Cultural Organization and the International Atomic Energy Agency, strengthen and co-ordinate international programmes for integrated pest control and reduction of the harmful effects of agro-chemicals:

(a) Existing international activities for the exchange of information and co-operative research and technical assistance to developing countries should be strengthened to support the national programmes described above, with particular reference to:

(i) Basic research on ecological effects of pesticides and fertilizers (MAB);

(ii) Use of radio-isotope and radiation techniques in studying the fate of pesticides in the environment (joint IAEA/FAO Division);

(iii) Evaluation of the possibility of using pesticides of biological origin in substitution for certain chemical insecticides which cause serious disturbances in the environment;

(iv) Dose and timing of fertilizers' application and their effects on soil productivity and the environment (Food and Agriculture Organization of the United Nations);

(v) Management practices and techniques for integrated pest control, including biological control (Food and Agriculture Organization of the United Nations and World Health Organization);

(vi) Establishment and/or strengthening of national and regional centres for integrated pest control, particularly in developing countries (Food and Agriculture Organization of the United Nations and World Health Organization);

(b) Existing expert committees of the Food and Agriculture Organization of the United Nations and the World Health Organization on various aspects of pest control should be convened periodically:

(i) To assess recent advances in the relevant fields of research mentioned above;

(ii) To review and further develop international guidelines and standards with special reference to national and ecological conditions in relation to the use of chlorinated hydrocarbons, pesticides containing heavy metals and the use and experimentation of biological controls;

(c) In addition, ad hoc panels of experts should be convened, by the Food and Agriculture Organization of the United Nations, the World Health Organization and, where appropriate, the International Atomic Energy Agency, in order to study specific problems, and facilitate the work of the above-mentioned committees.

APPENDIX II

Investigation	Location
(1) Fate and significance of insecticides and fungicides in soil of cocoa farms	Cocoa Research Institute of Ghana Tafo, Ghana
(2) Fate and significance of residues from insecticides used in rice cultivation with particular reference to environmental contamination i.e. residues in vegetables and paddy fish	International Rice Research Institute in collaboration with the College of Agriculture, Laguna, Philippines
(3) Fate and significance of acaricide residues in tea	Tea Research Institute of Ceylon St. Coombs, Talawakelle, Ceylon
(4) Fate and significance of halogenated hydrocarbon fumigant residues in cereals following treatment at farmer level	The Hebrew University of Jerusalem, Faculty of Agriculture, Israel
(5) Fate and significance of organophosphorus residues as a result of endo- and ecto-parasite control in cattle	Higher Institute of Veterinary Medical Science, Sofia Bulgaria
(6) Persistence of insecticidal residues as a result of locust control operations with particular reference to alternatives to dieldrin	Desert Locust Control Headquarters Asmara, Ethiopia
(7) Fate and significance of pesticide residues in cereal crops (especially rice) under Pakistan conditions	Department of Plant Protection Karachi, Pakistan
(8) Fate and significance of pesticide residues on tropical fruits for export	National Agricultural Institute Chapingo, in collaboration with the National Atomic Energy Commission Laboratory, Mexico
(9) Fate of pesticide residues arising in dates for export as a result of chemical control measures	College of Agriculture, Bagdad, in collaboration with the Nuclear Research Institute, Iraq
(10) Fate and significance of fungicide residues on bananas for export as a result of crown rot control	National Taiwan University Roosevelt Road, Taipei, Taiwan

(11) Persistence of pesticide residues in the environment following chemical control of tsetse flies	Makerere University College P.O.B. 2062, Kampala Uganda
(12) Fate and significance of residues arising from the use of fungicidal cereal seed dressings on wheat	Agricultural Research Institute Delhi, India
(13) Concentration by edible marine organisms of pesticide residues in estuary waters arising from agricultural run-off, etc.	IAEA Marine Laboratory Monaco
(14) Soil persistence and plant absorption of newer harbicides e.g. of the bipyridylium series	Agricultural Research Institute Nicosia, Cyprus
(15) Residues in harvested crops following use of the newer systemic fungicides such as Milstem and Benlate	Pesticides Department Faculty of Agriculture University of Libya Libya
(16) Persistence and significance of fungicide residues on citrus fruits for export	Department of Plant Protection Ministry of Agriculture, Jaffa, Israel
(17) Uptake and persistence of systemic O.P. insecticides in cocoa beans	University of Ghana Legon, Ghana
(18) Effect of different types of formulation (e.g. high volume or ultra low volume) on persistence of surface residues	Instituto Biologico, Sao Paulo Brazil
(19) Fate of pesticides in cotton seed oil following cotton pest control	Central Agricultural Pesticides Laboratory, Ministry of Agriculture in collaboration with Middle Eastern Radioisotope Centre, U.A.R.
(20) Fate and significance of pesticide residues in olive and olive products	Institute Phytopathologique Benaki Athens, in collaboration with Democritas Nuclear Research Centre Attica, Greece