CGIAR LIBRARY

EVALUATION OF CROP PROTECTION

RESEARCH, TRAINING AND TECHNOLOGY TRANSFER

at the

INTERNATIONAL AGRICULTURAL RESEARCH CENTERS

With Recommendations

Submitted to

TECHNICAL ADVISORY COMMITTEE

Consultative Group on International Agricultural Research

September 1989

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EVALUATION OF

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INTERNATIONAL AGRICULTURAL RESEARCH CENTERS

A STUDY COMMISSIONED BY THE

TECHNICAL ADVISORY COMMITTEE

OF THE

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

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SUMMARY

A panel of 10 crop protection specialists, each with experience at one or more International Agricultural Research Center (IARC) met in Washington, D.C. on July 11 - 13, 1989. The panel was asked to consider various dimensions of existing programs in crop protection at individual Centers including current research activities and issues, problems and constraints to crop production research, training and technology transfer with their partners and clients. The perceived need is to strengthen the gains already made in host plant resistance through additional research in crop protection in ways that will allow integration of the developed technology into crop protection systems. From these discussions came a number of options that would be expected to contribute to strengthening international crop protection efforts at the IARCs. These points formed the basis for developing some specific recommendations.

Some of the needs identified by the panel were:

- o More senior scientific staff qualified to conduct crop protection research, particularly in weed science and nematology.
- o Expansion of training activities in crop protection.
- o More networking of research partnerships.
- o Stronger alternatives for research organizations, especially to compensate for the site specificity needs of crop protection research.
- o Development of new methodologies, especially for prediction.
- o More access to modern communications technology.
- o More direct support for crop protection research activities.
- o Better approaches to the problems of site specificity in crop protection research.

An analysis of the current expenditures by IARCs shows them to be significantly underinvested in crop protection research. Most Centers typically allocate 6 to 8 percent of their budgets to crop protection research. Comparative values for public sector efforts in the United States shows crop protection research to be greater than 30% of the annual investment in the plant sciences.

The panel recognized that adjustments to correct this apparent underinvestment by the IARCs in crop protection research must be done in ways to support and supplement the existing and successful host plant resistance breeding programs while encompassing other tactics, methods and approaches.

The panel developed three options for consideration:

- o Network of Crop Protection Research - a coordinating network of scientists to provide improved communication and collaboration in research, training and technology transfer for crop protection. Participants in the network would include crop protection specialists and training specialists within the IARC community and others as appropriate.
- o Crop Protection Center-Without-Walls - a modest sized institution of scientific staff with project support but no fixed facilities. It would have a mandate providing programmatic flexibility thereby allowing the Center's scientists to pursue opportunities in collaboration with others as appropriate to the overall mission of the CGIAR member Centers.

- International Center for Crop Protection Research - a fixed facility with senior staff, supporting professionals and clerical workers with the assigned mission to conduct research, training and technology transfer in crop protection for the commodities of the CGIAR membership.

After thoroughly evaluating the proposed choices the panel recommended that the CGIAR give first consideration to establishing a network of crop protection specialists. This would be done with the intention of evolving, over a five-year period, to form a Crop Protection Center-Without-Walls. The advantages of a Center-Without-Walls would be its flexibility to address many of the present problems and constraints identified by the panel. The costs would be substantially less than maintaining a fixed Center. Additionally, programming, staffing and site selection would allow interdisciplinary team efforts to target and move to new problems as they are discovered, pursue opportunities as they arise and apply new technology as it becomes available. The senior staff for a Center-Without-Walls could be employed either directly through contract hiring for defined periods of time or indirectly with cooperating institutions loaning scientists through reimbursable, contractual agreements.

Other recommendations by the panel were:

- The Consultative Group on International Agricultural Research should establish a network of IARC crop protection specialists. The network would have the purpose of strengthening research coordination, collaboration and communication in IARC crop protection. It is further recommended that this network of crop protection activities be encouraged to evolve into a Center-Without-Walls. The timetable for this transformation might be over a 5 year period, allowing it to "ramp up" with senior staff hiring and project planning in research, training and technology transfer.

- TAC should consider fostering through the network an annual meeting of crop protection specialists from IARCs and partner institutions to promote communication and coordinated activities in crop protection research, training and technology transfer. A "summit meeting" would be a logical first step in establishing a network of crop protection scientists.

- Each International Center should identify a crop protection coordinator to serve as a contact for individuals wishing to establish linkages in crop protection research, training and technology transfer.

- All Centers should carefully review the emphasis now given to crop protection research as part of their on-going strategic planning process and provide senior scientists in crop protection opportunities to evaluate and plan new directions in crop protection research, training and technology transfer.

- TAC should address the policy issues of crop protection research with a view to all of the components of Integrated Crop Protection. Special reference should be given to the appropriate use of pesticides in Integrated Pest Management programs in Third-World situations. A TAC evaluation should include not only the issues of pesticide safety and handling, but food safety, environmental impact and public perceptions of the uses of pesticides in contemporary agriculture.

There is a sense of urgency to crop protection research inasmuch as many contemporary practices are considered hazardous, environmentally not sustainable and/or not fully dependable. In many areas fundamental knowledge is lacking on the basic biology and ecology of pests. A more systematic approach to research is needed to solve contemporary pest problems. The IARCs are in a unique and ideal situation to provide the necessary international leadership.

The challenge to improve crop protection technology will not be met easily. The complexity of the research, the difficulties of training sufficient numbers of people and the obstacles to crop protection technology transfer are recognized as substantial. However, this only argues in favor of greatly

increasing international investments in crop protection research, training and technology transfer to meet this pressing need.

INTRODUCTION

The International Agricultural Research Centers (IARC's) have made significant contributions to the improved production of crops on a global scale. Many of these contributions represent combinations of improved germplasm and cropping practices aimed at increased productivity, profitability and benefits for both the producer and the consumer.

Each year a portion of crop production is lost to pests as a direct consequence of their impact on the quantity and quality of the harvested and stored products. Other less direct effects of pests are the additional crop protection costs for materials and practices used to avoid or mitigate these problems. When considered together, the direct and indirect consequences of pests on crop production are substantial and hence, worthy of research into ways to better manage these problems (see Appendix K).

The mandates of the IARCs place them squarely in a situation of responsibility in crop protection research, training and technology transfer. This is particularly true inasmuch as pest problems are generally most abundant in the warm and humid environments of the tropics and subtropics. Moreover, some types of agronomic practices recommended for improved cultivars may predispose a crop to greater injury from pests. Practices such as increased nitrogen fertilizer, cropping intensity, genetic uniformity of crops, extended growing seasons, and patterns of planting can have significant consequences for the development of pests on certain crops.

This study was commissioned by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR). The challenge was to sift through an enormous amount of information derived from extensive activities from the International Agricultural Research Centers (IARCs) as well as their national program research partners. These partnerships have made major contributions to their clients who have benefitted from their innovative agricultural technology. The task of this study was to identify even better ways to organize IARC efforts to address contemporary crop protection needs.

TERMS OF REFERENCE

The Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) commissioned this study in early 1989 to evaluate the current crop protection activities at the CGIAR member International Agricultural Research Centers (IARCs), their partner institutions and their intended clients. The study was to focus on biotic agents that include insect pests, plant pathogens, weeds and other similar problems of crops. The study was not intended to evaluate abiotic stresses such as drought, soil nutrient deficiencies, etc.

The intention of the study was to 1) help in setting priorities for IARC crop protection research, training and technology transfer, 2) assist TAC in establishing desirable directions and emphasis for crop protection research, training and technology transfer and 3) provide insight on how global crop protection priorities relate to the broader questions of Center memberships in the CGIAR system.

This study was to view both the present and future degree of desirable focus for IARC activities in crop protection research. It also considered the comparative advantages of individual Centers, along with their current and planned resource allocations, for crop protection research.

In this context this study attempted to evaluate the short, intermediate and long-term view of crop protection research at CGIAR member Centers. The study considered potential new members to the CGIAR system and looked at existing and potential partnerships.

A previous TAC commissioned study of crop protection research efforts at the IARCs was used as an initial reference point. Additional documentation was kindly provided by the TAC Secretariat and the CGIAR library (see Appendix G).

The enormous responsibility for this study required special planning and approaches to ensure that adequate consideration was given to current and planned activities by the various International Centers. Moreover, TAC is, at present, undertaking a broad review of proposals to expand Center memberships within the CGIAR system. This TAC activity covers issues that extend far beyond crop protection research, and they are not directly covered in this study. There are, however, specific aspects of TAC's broader review, such as memberships for non-associated Centers, that could impact crop protection research within the CGIAR system. Thus, for what might otherwise have been peripheral to this study, the issues of non-associated Center memberships took on significance and were addressed. The appropriate non-associated Centers were then specifically evaluated for the attributes they would bring to the CGIAR system in crop protection research, training and technology transfer. This consideration extended the normal terms of reference beyond the CGIAR systems and their partners to form a third dimension.

As part of this study an assessment was made of the current research activities and directions in crop protection research projects at the IARCs. An analysis of activities by subject matter area was found to be useful for identifying gaps, compatibility, and overlaps.

The proposed Study Outline submitted to the Executive Secretary of TAC set the description for the scope of the study (see Appendix A). A Phase I Report was prepared for review in late April as a summary of certain documents for the Panel and to update the TAC Executive Secretary (see Appendix B).

MECHANISM FOR REVIEW

Any study of crop protection research activities at IARCs must cut across disciplines, span commodities, and extend over large geographic areas. Considerable information was available to support the study as program documents, annual reports, strategic plans and budget development activities (see Appendix G). Much of the written documentation, however, deals largely with the broad aspects of crop protection and not the specifics of research approaches, training issues, or detailed aspects of crop protection technology transfer, especially for IARC client groups. It is for this reason that an innovative approach to the study was adopted to gather information on activities, issues, problems and options that might contribute to strengthening crop protection research at IARCs and their partners.

The innovative approach used a panel of 10 crop protection scientists, each of whom has had extended employment at one or more IARC, but who is currently employed in another research organization. The intention of this approach was to obtain non-vested interest along with first-hand knowledge and experience of the CGIAR system. The panel membership is presented in Appendix C with a brief description of the professional history for each member.

In addition to the panel participants, one observer was invited to represent the research perspective of chemical control of pests. Dr. Charles Delp has a distinguished career in pesticide development with private industry, and has made significant international contributions as a professional in crop protection.

Funds for support of the three-day conference were made available from the TAC study grant, funded through the World Bank. This expenditure represented a major portion of the resources allocated for the study.

The panel was assembled in Washington, D.C. on July 11 - 13, 1989. The agenda for the meeting is presented in Appendix E.

Four critical questions were addressed during the meeting:

- What are the issues facing the IARCs in crop protection research?
- What crop protection problems will the IARCs need to address in the next decade?
- What are the present constraints to crop protection research at IARCs?
- What changes should the CGIAR system consider to improve crop protection?

The highly structured meeting procedures of Andre Delbecq, called the Nominal Group Technique, with modification, were used to address the four central questions. From those questions the panel generated numerous suggestions which were each posted on flip-charts, discussed and organized by category and priority. Those items, identified by the meeting participants, along with numerous documents supplied by the CGIAR library, form the basis for the observations, assessments, and recommendations of this report.

CONCEPTS IN CROP PROTECTION

Pest control activities can be classified into the following three areas:

- o Exclusion
- o Eradication
- o Crop protection

Exclusion of pests is perhaps best exemplified by phytosanitation regulations that restrict regional movement of insects, weed seeds, and pathogens by human activities. Research in seed health and tissue culture technology have contributed significantly to these exclusionary strategies. New technologies are constantly being developed to facilitate the safe international exchange of germplasm. These technologies reduce the risk of introducing pests into areas where they do not now exist. Many of the IARCs have seed health and tissue culture research programs which contribute significantly to phytosanitation programs. These activities are very worthwhile and should be encouraged. They are, however, not considered part of this study which focuses on crop protection.

Eradication, another strategy used in pest control, is of questionable application in many instances. Some examples of successful pest eradication do exist, but the enormous cost and the problem of recurrence often weighs against this strategy. There is apparently very little research being conducted on eradication of pests, and it seems unlikely that the IARCs would benefit by directing research resources in this area. Again, eradication is not considered relevant to this study.

Crop protection tactics include:

- o Host plant resistance
- o Mechanical practices
- o Chemical treatments
- o Cultural practices
- o Biological control

Host plant resistance has been successfully used in a great number of applications for crop protection. In many instances host plant resistance to pests has proven effective for considerable periods of time. In other cases, the host plant resistance is overcome by variation in the pest population, leading to a "breakdown in resistance". Significant research activities are currently underway in advanced laboratories to uncover "durable resistance". Many theories have been advanced to explain why some forms of host plant resistance remain effective for long periods of time. But, as yet, no clear-cut explanation for the observations exists.

The advantages of using host plant resistance are obvious. Once a cultivar is selected, its incorporation in to a crop production system is relatively easy, especially when compared to other crop protection tactics. The disadvantage of relying solely on host plant resistance is the problem of genetic unreliability which has on some occasions led to pest epidemics, unstable production systems and reliance on pesticides as a fall back position.

Mechanical control of weeds is a well accepted practices and remains viable in some production systems. The effectiveness of these practices rests primarily with timing and frequency of weedings. Mechanical practices for insect pest and plant pathogens are less well understood. But there is a growing body of scientific knowledge showing that certain agricultural practices such as deep plowing, debris removal and similar activities can reduce the initial amounts of a pest, resulting in better crop protection. This may, however, negate the advantages of leaving crop residues on the soil surface.

Chemical treatments are used to control pests of crops but are coming under close scrutiny from many sectors. The fact remains, however, that worldwide, agriculture is dependent upon pesticides for some aspects of crop protection, including quality of harvest and post-harvest storage. Arguments about the use of chemicals in agriculture are very complex and include concerns related to public attitudes, environmental protection, economics, public health and the sustainability of the control practices.

Cultural practices such as planting date, intercropping, flooding, row spacings, seed bed preparation, amount and type of fertilizer, mulching, and similar agricultural production activities have significant effects on pest dynamics, and consequently crop productivity. In many instances, too little knowledge is available to develop a full understanding of how our cultural practices contribute to pest and disease outbreaks. This has greatly restricted the exploration of how to use cultural practices in crop protection.

Biological control tactics are presently seen as the "new wave" of environmentally sound solutions to problems in crop protection. Biological control uses the natural interactions between living agents to combat pests in crops. These practices are said to be more harmonious with the environment and safer to apply. Biological control represents a rich area of potential applications to contemporary problems in crop protection through biotechnology.

Integrated tactics

There are significant differences in the various uses of the tactics of crop protection in agriculture. Over the past two decades there has been a trend in research away from attempts to achieve total pest control to more of a management approach. This philosophy recognizes that biological dynamics and economic realities weigh in favor of accepting some level of pest in a management strategy. More recently we have seen the integrated approach which combines tactics and is best exemplified by the philosophy of Integrated Pest Management. This approach, first put forward by research entomologists, is now well accepted by all crop protection disciplines.

Integrated approaches to crop protection have highlighted the need for interdisciplinary research activities including team research by commodity or cropping system. This is regarded as a healthy practice for several reasons, including more economically and environmentally sound pest and disease management programs. Integrated approaches have also revealed a need to develop decision theory (i.e., when to take action) based on the economics of predicted crop losses and the costs of the control measure. This too has been a healthy turn of events for research philosophy in crop protection, most notably in the last decade. This broadening of view has encouraged consideration of social and cultural distinctions in crop protection research for a more holistic approach to problem solving.

As the horizons of crop protection have expanded, some of the research has taken on aspects of systems science. More and more researchers have come to recognize that crop protection is a component of the production system related not only to profitability, but to the sustainability of that system as well. This recognition provides a valuable interface for addressing environmental issues such as the impact of crop protection practices on the environment including environmental pollution from the use of pesticides, and cultural practices that promote erosion.

As crop protection research accepts a broader view of related issues such as interdisciplinary work, socioeconomic factors, systems science and environmental consequences, the complexity of the research has grown exponentially. This fact represents one of the greatest challenges to the management of contemporary crop protection. The IARCs have not been able to take full advantage of these new developments as a full array of IPM tactics and philosophy.

IARCs AND CROP PROTECTION

The IARCs have made undeniable contributions to global crop production - both directly through research and indirectly as international leaders providing new research directions. The Centers contributions to crop protection are most obvious in the areas of host plant resistance through crop improvement. The IARCs have served as critical links in the development of resistant germplasm, in improved germplasm distribution and for developing the research methodologies needed to breed resistant cultivars. The International Centers' activities in germplasm collection and preservation have also provided the necessary genetic resources for these research activities. The IARC's leadership role in providing new directions for research has meant that many national programs have also highlighted host plant resistance as their primary means of crop protection.

The remainder of this report looks at several questions related to the appropriate boundaries of crop protection research for individual IARCs. Consideration was given to commodity orientations, client groups, and the recognized logistical difficulties of conducting some aspects of crop protection research, training and technology transfer.

One of the tasks of the July 11 to 13, 1989 meeting was to evaluate the extent of commodity research activity for each of the IARCs. The intention of the evaluation was to look at the present balance of the components of crop protection research activities to identify areas of comparative advantage for various Centers relative to their collaborating partners and clients.

Each panel member approached the evaluation process with a sincere appreciation for the enormous contributions that have been made by the IARCs. The information in the next section represents a consensus judgement on research activities and is not a reflection on the quality of the efforts or the value of expected outcomes. Because the experience of the panel varied by Centers, some verification of the assessment values may be needed. The values presented should be viewed as a summary assessment of current research investments in specific aspects of contemporary crop protection research.

CURRENT ACTIVITIES ANALYSIS

A detailed analysis of IARC crop protection research activities was undertaken by the panel participants during the July 11 to 13 meeting. The purpose of this "activities analysis" was to systematically evaluate how different Centers were organized and how crop protection resources were allocated. The assessment was 1) the level of activity in certain research categories (Tables 1-8), and 2) the financial resources allocated to crop protection (see Appendix H).

The research activities were categorized into Tactics, Implementation, Methodologies and Approaches.

Under Tactics, the panel considered:

- o Host plant resistance
- o Mechanical practices
- o Chemical control
- o Cultural practices
- o Biological control

Under Implementation, the panel considered:

- o Surveys (e.g., seedling nurseries to assess pathogen race patterns)
- o Monitoring (e.g., trap nurseries)
- o Forecasting (scouting and weather prediction)
- o Loss assessment (e.g., single and combined effects of biotic agents)
- o Economic thresholds (decision theory)

Under Methodologies, the panel considered:

- o Modeling biological systems
- o Population dynamics of plant pests
- o Biology and ecology of plant pests

For Approaches, the panel considered:

- o Integrated Pest Management strategies
- o Socioeconomic considerations
- o Farming systems perspective
- o Integrating animals into crop production systems
- o Sustainable development of each of the above

The panel members arrived at their evaluations by consensus following point by point discussion. Individual Centers were taken in alphabetical order, and considered for each of their commodities. Assessments were based on a scale of 0 to 4 with 0 representing no research activity recognized at

this time. Intense research activity on a topic was given a 4. The evaluation data are provided in Tables 1 through 8 of this report.

It was well recognized by the panel that not all Centers should or would want to be all things to all people in crop protection. It was not the panel's intention to offer any implied criticism for activities not undertaken. In many cases some of the Panel participants stated that choices made by Centers not to invest in certain crop protection research activities seemed reasonable.

The pattern of crop protection research activities discernable across Centers indicated a strong commitment to developing host plant resistance. This is consistent with the history of the International Centers, and their strong emphasis on the genetic improvement of specific commodities coupled with the transfer of that technology through seed distribution.

The host plant resistance approach to crop protection has an interesting consequence. For those pest problems with significant genetic variability, host plant resistance is often rendered ineffective. Hence, many of the International Centers must devote considerable resources to "maintenance research" to replace cultivars on an almost regular schedule. For instance, CIMMYT estimates that 2/3 of its total research efforts in wheat improvement relates to maintenance research, with crop protection activities primarily, but not exclusively on disease resistance.

Host plant resistance research has only indirect application to weed management. With the exception of a few Centers, only minimal weed management research is evident. Significant contributions could be made by the Centers to understanding weed biology and ecology, and in determining threshold levels for the primary weed species of important production regions.

The panel noted some research activities at some of the Centers worthy of special note. Cultural control research at CIP was judged as very significant. These efforts are complemented with significant activities in surveys and monitoring. CIP is approaching crop protection research through Integrated Pest Management coupled with an active research program in pest biology and ecology.

IITA is recognized as having a highly active program in biological and cultural control of cassava pests. These activities are well complemented with implementation research on surveys, monitoring, crop loss assessment and economic threshold research. Activities in pest modeling and fundamental research in pest biology and ecology are also very strong in the IITA cassava program.

In addition to the host plant resistance research efforts at CIMMYT for maize and wheat, the Center has very active programs in global nurseries, surveys and monitoring for wheat pests that complements well their plant breeding efforts.

Implementation research activities at IRRI are also very strong in nurseries, surveys and monitoring as well as crop loss assessment and economic thresholds. Moreover, significant research activities in modeling, population dynamics and pest biology and ecology are seen as supportive of their overall program. It is noted that they are using a farming systems approach to their crop protection research for rice. This is complementary to WARDA's highly active research approach through sustainable development.

A similar activities evaluation of the crop oriented non-associated International Centers was undertaken by the panel using the same scale. This allowed the panel to identify the attributes of crop protection research that each might bring to the system through membership.

The panel clearly recognized the strength of activities at ICIPE in basic insect pest biology and ecology. It also took note of the activities in cultural and biological control of insect pests and in modeling and population dynamics approached with a socioeconomic perspective.

AVRDC was seen as having strong research activities in host plant resistance and cultural control practices for several vegetable crops.

ICRAF research activities in crop protection were noted as strong for pest monitoring, loss assessment and economic thresholds plus significant research on chemical control practices, particularly those directed at weed management.

The fourth non-affiliated Center considered by the panel for their crop protection research activities was the INIBAP which was noted as having modest levels of effort in host plant resistance and chemical control research.

There is a dilemma presented in the crop protection research activities of the IARC's that needs to be addressed. On the one hand it is recognized that the Centers provide models that are emulated by national programs around the world. By having highly respected research programs, the Centers continue to provide leadership in agricultural research. On the other hand, any attempt by a Center to address all aspects of crop protection would stretch their resources to critical levels. The Centers must therefore continue to exercise some restraint to achieve a balance between their quest for excellence, and trying to be all things to all people.

The challenge that was addressed by the panel members was to attempt to realistically consider how the existing CGIAR system, that works so well for the genetic improvement of crops, can be complemented and not weakened by additional research in crop protection. The perceived need is to strengthen the gains already made in host plant resistance through additional avenues of research that have realistic requirements for resources.

The recognized role of training, as a compliment to IARC research efforts and the need for effective technology transfer mechanisms was also addressed during the panel's deliberations. The IARCs are recognized as having a strong comparative advantage in training, both in short-term workshop settings as well as in non-degree instruction. It was recognized that the proper balance between research and training differs by Center, according to commodity and is resource dependent. Some panel members noted, however, that many IARCs have isolated their training programs from their research scientists to the detriment of both activities. The benefits of IARC training activities in crop protection are seen not only in the multiplier effect (obtained from training the trainers) but also in the intellectual stimulation received by the IARC scientists through participation in the training programs.

The activities analysis of IARC crop protection research is interesting when compared to the budget allocations to crop protection research by the Centers (see Table 9 and Appendix H). Most Centers allocate 6-8% of their total budget to crop protection research. ICRISAT was the exception, allocating over 12% to crop protection. This appears inconsistent with the panel's activities analysis of ICRISAT and may represent differences in the assignment of portions of Scientist's Years to multiple research activities.

When compared to other public sector agricultural research institutions the IARCs appear to be significantly underinvested in crop protection research. For instance, the FY 1987-88 public sector investment in crop protection research in the United States of America exceeded 30% (see Table 10 and Appendix I). By this measure the IARCs would need to increase crop protection research allocations by more than 400% to proportionally match current U.S. public sector investments. This is, of course, an arguable point. However, if the IARCs choose not to direct major efforts to crop protection research, who will? Most of the national programs in the Third World are not in a position to provide contributions to modern crop production research programs of the scope necessary to be of major significance. Finally, the best available estimates of worldwide pest caused crop losses point to 25-30% losses annually. This magnitude of damage certainly justifies significant investments in crop protection research by the IARCs.

ISSUES

The panel identified a large number of issues related to crop protection research for International Centers, their clients and their partners. For clarity of presentation these issues have been organized into groups.

Policy Issues:

Some confusion continues over Center mandates and commodity responsibilities within the CGIAR system. This confusion impacts crop protection research as problems go unaddressed or become difficult to address without clearly defined responsibilities. These difficulties are sometimes compounded with inconsistencies in management policies within Centers that leave questions unanswered for crop protection program leaders. Directly stated, written mandates that deal with the issues of crop protection are needed to specify responsibilities and promote intercenter collaboration on a continuing basis.

An important crop protection research issue at the policy level is the apparent lack of institutional acceptance of a systems science approach for research in crop protection. Acceptance of a holistic or "system perspective" would contribute to better facilitation of interdisciplinary team research and more workable relationships across disciplines. This issue is related to the strong concerns of the panel for the philosophical direction at Centers. At many Centers a view is needed that extends beyond the singular use of host plant resistance to address the more complex issues of Integrated Crop Protection.

Another policy issue is the need to work with policy makers in understanding how their decisions impact crop protection implementation. For instance, the use of artificial price supports often significantly deters certain types of crop protection practices that would otherwise be acceptable and useful. There is a need to organize agricultural policies as they impact crop protection strategies in both the short-term and long-term. Exactly who might undertake this type of responsibility is addressed later in this report.

The panel participants also identified the need for more evaluation and accountability in crop protection research than is presently evident. This could be done through the establishment of criteria to evaluate the progress of various research activities. A program of evaluation and accountability would allow for more planning of program directions and better distribution of resources to opportunity and need.

Additional policy issues included the direct and indirect impact of crop protection research on human nutrition, food safety, human health, and family food security. These are contemporary issues that are related to significant alterations of crops through breeding (host plant resistance), and through the application of pesticides during crop production and storage. Moreover, in the not too distant future, additional questions will be raised on the safety of genetically engineering organisms for crop protection. This will be true for field tests of crops altered for enhanced host plant resistance as well as for the biological control agents expected to be produced through biotechnology.

Other policy issues that need to be systematically addressed in relation to crop protection research are sustainability, biodiversity, (especially of host plant resistance sources), gender issues (particularly in the application of pesticides), equity issues (appropriate crop protection technology for small holders), and environmental issues (e.g., soil erosion and pesticide contamination).

Research on pesticides also represents a policy issue in need of resolution. International Centers presently differ in their policies on pesticide research. The explanations for these differences are not all that obvious. Pesticides play an important role in contemporary agriculture. But there are complications to investigating their proper and appropriate use. Pesticides, in the minds of many, are now perceived to represent greater risks than benefits. In some cases this has resulted in a backlash against Integrated Pest Management which may use pesticides as one of the tactics. The panel participants asked -"If some Centers choose not to do research on pesticides, are their client's best interests served?" Moreover, on who's shoulders should fall the burden of addressing the well-recognized problem of pesticide abuse that now occurs in so many IARC client countries? The issues of pesticide safety, residue analysis, pesticide storage, application technology and many other

important topics are apparently not now being adequately addressed through research, training and technology transfer at either the national or international level. If it is a conscious decision by the IARCs that they should not be involved in these aspects of crop protection, then how should the IARCs encourage others to assume this responsibility? Who will provide the necessary integration of pesticides into crop protection practices for commercial agriculture? (see Appendix J.)

Some of the panel's identified policy issues dealt with legal and regulatory aspects of crop protection research. One of these is the emerging need for the International Centers to address questions pertaining to intellectual property rights (e.g., patents). Clearly stated patent policies are needed for dealing with the Center's partners in developed countries (especially for genetic engineering). This issue has reached the point of demanding immediate attention.

A second legal issue that needs to be addressed by the IARCs is that of professional liability. What protection is now afforded principal investigators as they undertake research in crop protection? Some crop protection activities may lead to litigation. Should some insurance be provided to protect them as individuals and as employees of the Center?

Another unsettled area is phytosanitation. The International Centers are very dependent on exchanging biological materials restricted under international phytosanitary regulation. This issue is very important, not only to the breeding programs exchanging seed but to crop protection scientists exchanging microbiological isolates, insect cultures and similar biological materials critical to their research programs. It is well understood that no International Center would willfully violate known phytosanitation regulations. But the problems of unnecessary regulation and the existing disharmony of national regulations, from the perspective of the International Centers dealing with many nations, needs to be addressed. This should be done through an orderly development of a policy that will provide needed phytosanitary protection and for the needs of science as well.

A related issue for International Centers is that of public relations, particularly in crop protection. The Centers must deal with issues such as pesticide research, exotic biological organisms, biotechnology and similar sensitive investigations that are presently in the public's eye and subject to controversy.

A re-definition of the boundaries around a Center's mandates is needed. This new view should facilitate a systems approach to crop protection by dealing with items such as non-mandated crops important as components of major cropping systems. New mandates would also help in approaches to problem solving on topics such as biological control and how best to integrate tactics into present crop protection programs. For instance, many of the IARCs continue to deliberate over the mission issue. Is their proper role coordination of international research or simply do the research themselves? Most centers now strike a balance between coordination and hands-on activity. But that balance is changing. This is very evident in the strategic plans for most of the Centers. The question for crop protection research is - "How will that new balance be obtained?"

One of the suggestions developed by the panel participants was to have the Centers take a fresh look at collaborative research through new networking partnerships. Does private industry have a future role to play with the IARCs? What kind of innovative programs could IARCs develop with the private sector? And how do the IARCs piece together that relationship with other public sector partnerships and with national programs? Finally, on this issue, who is (or are) the target group(s) for crop protection research? And does that answer differ for other research activities at the Centers?

Issues of Program Approach:

The benefits of a holistic or systems approach to crop protection research was accepted as a consensus by the panel participants. A holistic approach to research would most likely come through a cropping systems perspective which would also work towards a more sustainable agriculture. Questions were also raised regarding missed opportunities for integrating animal production into crop production practices to capture anticipated benefits in crop protection.

The panel saw a need to address crop protection strategies in subsistence agriculture and in traditional farming systems. They also saw the need to evaluate crop protection strategies in non-traditional

production areas, especially where environmental stresses may predispose a crop to certain biotic agents. Finally, culturally adapted recommendations for crop protection were considered important for the implementation of new crop protection technology in different cultural settings.

Concern was expressed by the panel for the apparent overemphasis in some programs on short-term crop protection goals. Some researchable topics in crop protection may require long-term investments in research. Biotechnology is one such area. Biotechnology pay-offs may be in the long-term but they represent striking opportunities to significantly reduce crop protection inputs for some types of crop production.

Issues of Research Coordination:

International Centers have an importance that goes beyond their research contributions to that of international coordination of research activities. The IARCs serve as institutional models for national programs. This aspect of the International Centers represents a distinct attribute that can be used to coordinate research and develop necessary "critical masses" to address problems, especially in crop protection. It is this aspect of leadership, in addition to their research strength, that provides the IARCs with unique opportunities to magnify their contributions through partnerships.

This point raises the question of how best to establish the research agenda and select priorities when serving as both a coordinator and a partner. The panel saw a need to establish a set of criteria for evaluating research activities and their impact on crop protection (see Appendix K). This would assist not only the Centers in planning research, but would also help their partners and client programs in adopting these priorities.

In crop protection, the panel saw an apparent need to identify the corresponding institutions that are available to serve as collaborators. This would help to strengthen inter-institutional cooperation. At present, this type of collaboration has not reached its full potential. The question was raised "Can the Centers and their partners do a better job of sharing resources to assist each other in conducting crop protection research?" Attendant to this question is the additional issue of non-affiliated Center memberships in CGIAR. The panel recognized that adding new Centers could increase the commodity inventory and perhaps further stretch the CGIAR's crop protection resources.

Partnership Issues:

The panel clearly recognized that the comparative advantages of the IARCs relative to the National Agricultural Research Systems (NARS) is diminishing as the national programs increase their plant breeding programs. This then raises the question - "What are the appropriate future linkages with the national programs, regional activities and various subcenters?" The entire issue of networking, particularly as the Centers move "upstream", raises new specific partnership issues.

Intercenter Issues:

The research networking issue is also of importance between Centers. In some cases research networking is presently seen as too weak or detrimentally competitive with the perception of poor intercenter communication in crop protection. This issue should be addressed in ways to strengthen international crop protection research activities.

Interdisciplinary Issues:

The panel saw a need for more research on the interactions between pests as they combine to contribute to crop losses. There is a clear need to investigate more thoroughly production practices that impact pests, their interactions with crops and livestock and the socioeconomic dynamics of various cropping systems. This represents a clear and present challenge to the IARCs to provide the necessary resources for such interdisciplinary research.

Technology Transfer Issues:

A major issue for the International Centers is how best to assist national programs in crop protection technology transfer. This is an important issue for crop protection technology implementation that will soon receive critical evaluation in another study now being planned by the Australian government and others.

Some experts presently assert that there is sufficient technology available on Integrated Pest Management waiting to be put to good use. The question is -"How best to get it into use?" [Note: Other experts dispute the extent of crop protection technology awaiting application and argue that what is needed is more research activity.]

The innovative IPM technology transfer program of FAO scientist Dr. Peter Kenmore entitled "Introductory Programme for Integrated Pest Control in Rice in South and Southeast Asia" has demonstrated significant success. This project is worthy of close study by the IARCs. Dr. Kenmore has mostly focused on training individual farmers in specific aspects of Integrated Pest Management (e.g., recognition of beneficial insects). But is this approach too intensive for the IARCs? The advise of professional technology transfer experts is needed and recommended.

The present pattern at many Centers appears to be withdrawal from regional (outreach) subcenters. The often cited reason for this move is that they are too costly for effective technology transfer which raises the question - "How will new knowledge be disseminated?" Should the IARCs be restructured in some way to deal with technology transfer in the form of an extension service? What is the appropriate balance of crop protection research and technology transfer for the Centers? Should there be an attempt at IARC outstaffing to the national programs, and at what cost? What is the appropriate balance between research, research coordination and technology transfer? These issues need to be resolved or they will continue to be problematic for the implementation of crop protection discoveries.

Training Issues:

The panel was very undecided on the best approach for training in crop protection. Although there was a general recognition for the need to increase IPM training at the Centers, how this would be done remained an unresolved issue, given current resource constraints. The advise of professional training instructors is needed and recommended for this topic.

Pesticide Issues:

Pesticide technology has played an important role in agricultural crop protection globally (see Appendix J). There are many research topics related to the appropriate uses of pesticides including efficacy, application technology, worker safety, persistence, and disposal. There are also important pesticide use issues for human health, impact on non-target species and residues in food, soil and water. There are concerns for pesticide environmental impacts, exposure, and registration problems. These issues are presently not well addressed in the Third World. Do these issues represent appropriate activities for the IARCs?

The particularly difficult issues of pesticide resistance management and pest resurgence was discussed by the panel vis-a-vis the IARCs. Research on these problems would seem to be appropriate efforts at some, but not all, of the IARCs.

Safety issues for users (such as appropriate protective clothing, safety training, labeling for illiterate farmers and equipment) are other topics that should be considered by the Centers. This could be done either directly, in collaboration, or by encouraging others (partners, FAO, clients, private industry, etc.) to undertake these responsibilities.

The proper role of pesticide in Third World agricultural production, including safe and effective use, is an important issue if yield gains obtained by genetic improvement are to be realized. This issue needs to be addressed at the policy level.

Sustainable Farming:

There is today a broadly recognized acceptance of the desirability of sustaining agricultural production. After all it is in everyone's best interest. However, development of sustainable agriculture technology is a complicated task. Efforts in sustainable agriculture research will directly involve crop protection technologies. This research will quite likely involve complex ecosystem analysis of the crop's pests. There is need to develop crop protection practices that minimize environmental impact, conserve natural resources and provide economically acceptable crop protection practices. This is a big order that will need to be addressed in the long-term and on a continuing basis.

Crop protection practices quite often represent a significant portion of the cost of producing a crop. Consequently, the economic feasibility of crop protection practices is an important issue for International Centers to consider. The profitability of farming is quite often protected by artificial price supports that greatly distort the value of crop protection practices, often with negative consequences. These issues directly impact decisions on crop protection research, training and technology transfer in complicated ways and they must be better understood by the International Centers as they plan programs and set research priorities in crop protection.

PROBLEMS AND CONSTRAINTS

The panel considered a number of problems and constraints influencing crop protection research, training and technology transfer from the perspective of the IARCs, their partners and their clients. These items are presented by categories for editorial purposes.

Research Infrastructure:

The panel recognized the need for increased "intellectual capital" (i.e., people) in crop protection research in the IARC system. Several glaring deficiencies were noted such as an under representation of weed scientists throughout the system and too few specific crop protection specialists in commodity areas at individual Centers. Also recognized was the need for greater integration of discipline activities for crop protection problem solving at the IARCs.

Library and bibliographic services in crop protection were identified by some panel members as insufficient at some Centers for both research and training.

In the area of the regulation of biological control agents, current national regulations for beneficial insects have become a constraint to international crop protection research. Added to this is the disharmony of the various national regulations which directly affect not only conventional research but will sometime soon impact biotechnology research in crop protection. Biosafety regulations for field testing genetically modified organisms is a problem that will grow in importance for the IARCs.

The panel recognized the importance of germplasm resources and the need for giving further emphasis to collecting, evaluating and preserving genetic material to serve as sources of host plant resistance. There is also a need to work out new techniques and methods to maintain those genetic resources in germplasm banks.

Technology Transfer:

A better technology transfer program is needed to support the IARCs activities. This is probably not a problem unique to crop protection but is an underlying fundamental constraint to international agricultural development. No solution to the problem was offered by the panel, but they placed a high priority on programs addressing this issue.

Communication, Coordination and Organization:

There was a general consensus among the panel members for the need to strengthen IARC leadership in interdisciplinary activities in crop protection. There is a need to increase interactions with recipient countries and help increase collaboration with developed countries scientists in crop protection research. It would also contribute to improving existing technology transfer systems.

The Centers are perceived as having low appreciation for the important coordinating role they could play in crop protection research globally. By coordinating IPM activities across Centers and facilitating better intercenter communication, activities in crop protection research, training and technology transfer would likely be improved. This might be done through the establishment of a communication network involving new partnerships with public sector institutions, and perhaps even linkages to private industry. One model might be CIAT's cassava and bean research information centers which abstract all literature pertinent to these crops. Could a similar service be performed for crop protection?

Program Aspects:

The IARCs are deservedly recognized for strong research programs giving emphasis to host plant resistance. The panel's concern was that too much emphasis on host plant resistance may detract from other aspects of crop protection, which may then be viewed indifferently or as nonessential. This

attitude towards program priorities has, in the view of the panel, contributed to inadequate staffing in crop protection and to low levels of funding for the broader areas of crop protection that extend beyond host plant resistance. Thus, it was observed, new research directions in crop protection have not been vigorously pursued by the IARCs.

Demands and Rewards:

Senior scientists at the IARCs are said to have high demands placed on them to participate in non-research activities. This contributes to frustration and inefficiency for the senior staff. The panel also noted that there is often a lack of time for crop protection research planning. This is coupled with the feeling that there are too many time consuming reviews at the Center level and not enough in-depth peer reviews at the program level.

The panel noted that some people expect too much from the Centers. This was seen as particularly true for national programs which sometimes place excessive demands on individual project resources. [Note: The corresponding complaint of IARCs expecting too much of national programs has also been heard, underlining once again the need for better communication and coordination.]

Many scientists see IARC senior staff positions in crop protection as unattractive career paths. This constrains the hiring and retention of high quality scientists. This then contributes to high rates of senior staff turnover and consequently, a lack of continuity in research programs in crop protection. This problem was recognized by the panel as very significant.

Finally, some Centers do a better job than others in providing for the quality of life and social environment necessary to attract quality scientists. Those IARCs that do not meet this need have as a consequence diminished opportunities for recruitment and retention of the best crop protection scientists.

Personnel:

The limited quantity and quality of technical assistants for crop protection research programs are recognized as constraints in most IARC crop protection programs. In many cases there is a virtual absence of well-trained national research assistants that have necessary contemporary skills. This problem is compounded by the lack of opportunities for national staff to receive training in needed technical areas or to pursue advanced degrees, which seriously affects morale.

Research topics:

As noted earlier, the IARCs are underrepresented in weed science broadly and in some cases, underrepresented for individual crop protection disciplines. This underinvestment in crop protection at the IARCs has constrained research activities and limited the development of strategic and applied knowledge in crop protection.

There is a growing awareness at the IARCs of the need to move "upstream" in many areas of research. Just how this shift will affect research in pest ecology and biology is not apparent from most of the IARC strategic plans. The panel noted the desirability of developing more fundamental knowledge in these areas, while recognizing resource constraints. In some areas of crop protection significant amounts of knowledge await implementation (see next subsection). In other areas, the lack of fundamental knowledge limits conceptual approaches and solutions to problems. Collaboration with outstanding centers of excellence in the U.S. and Europe could be of enormous value.

The panel recognized some broad areas of crop protection research that should be included in future program designs. These include the issues of production sustainability, climatic changes, genetic vulnerability and declining and/or marginal yield increases.

The panel saw a need for more efforts towards documenting real versus perceived pest problems for IARC mandated crops. Research studies are needed on pest interactions along with better methodologies to determine the impact of pests on crop yields. There is also a need for appropriate

protocols for field surveys of crop losses and better procedures for the measurement of biotic stresses on crops to improve pest management tactics and for better assignment of action thresholds. This is especially true for mixed pest problems which are coming to be recognized as important.

Although crop protection research is, in many instances, site specific, some aspects of the research are not. These activities include crop and pest modeling, genomic mapping, basic biological and ecological research, and socioeconomic evaluation. These topics might be suitable candidates for inter-center collaborative projects, partnership projects with other institutions or for contract research (sensu CIP).

In the area of host plant resistance, basic understanding is needed on the mechanisms of resistance especially for stable or "durable" resistance. This information is needed to move forward on many fronts (including biotechnology) for more desirable host plant resistance.

Other constraints to crop protection research include the lack of technology for pest forecasting. In addition to poorly understanding the effects of weather on biotic agent buildup, the dynamics of pest population genetics are not well understood and these are areas in need of research.

There is a need for more study of migratory pests through spatial analysis. This type of knowledge would allow for more complete pest management programs. Finally, through the opportunities offered by biotechnology, new insights into the genetic variability of pest populations will help scientists develop better approaches to the problems of variable pests and, hopefully, resolve the problems of transient host plant resistance.

Pest control technology for stored products is another area of crop protection research that deserves more attention along with research for the management of mycotoxins and natural plant toxins in harvested products.

Some specific research topics identified by the panel participants included the need for more long-term research on locust and additional research into bird and rat damage. They also saw a need to provide greater research program flexibility to allow for prompt responses to new pest problems as they arise.

The topic of allelopathy was recognized as an important area of research that could be more fully explored by the IARCs or their partners for applications in weed management.

More effective diagnostic techniques are needed for identifying biotic agents. Such tools would contribute directly as applications to their research studies. They would also have use in pest management programs in production agriculture.

Implementation:

Several panel members recognized that sufficient knowledge is currently available to begin testing and deployment of improved crop protection technologies. It is, they say, the implementation programs that are lacking. Related to this constraint are the questions -"What is appropriate technology for Integrated Pest Management?" "How are pesticides to be employed in an IARC developed IPM program?" "Who is the target audience?" These are, of course, not only research issues constraining IPM implementation, but a policy issue as well (as noted earlier).

One aspect of IPM that constrains implementation is the apparent complexity of the many current practices. One suggestion was to undertake research to simplify IPM. This might be done through the development of appropriate field level decision tools or communication devices, such as pest identification field books.

There is also a need for developing more appropriate training programs for IPM teams from national programs. An increased role in training in crop protection by the IARCs could have significant dividends through "training the trainers" to gain the multiplier effect. But, as noted earlier, given limited resources, it does not seem possible for the IARCs to accept this added responsibility. They could however, develop stronger collaborations with other institutions such as CATIE, FAO, CICP and

ICIPIE to support, participate and accelerate aspects of crop protection research, training and technology transfer. To do this will require some network of communication that does not now exist.

NEEDS ASSESSMENT

The panel identified the following needs to strengthen the capacities of IARCs in crop protection research, training and technology transfer:

Size of Staff

There are too few senior staff working with underutilized but excellent facilities and equipment. To address this deficiency in "human capital" the IARCs need to attract qualified scientists and retain them for periods of employment long enough to make significant scientific contributions. There appears to be insufficient "critical mass" for some activities. Weed science and nematology are particularly notable in this deficiency.

Training:

The existing training programs have a great impact on national program research, but they are having much less impact on crop protection technology transfer or training. It appears that this is, in part, a consequence of the high cost of the contemporary IARC training model and the insufficient mechanisms presently used for most IARC crop protection outreach programs. This situation should be carefully studied to find a more cost effective alternative.

Networking:

Better networking with various research partners is needed to develop stronger collaboration on a global scale. A "task force" approach is needed with an inter-Center perspective coupled with an effective mechanism for choosing research partners.

Organized Research:

The various approaches used by the Centers to organize crop protection research should be studied to identify stronger alternatives. Some of the points to consider for such a study might include a reevaluation of the balance between direct ("hands-on") crop protection research versus the coordination of activities with others. The need for site specific information requires research to be done in appropriate areas. This necessitates working more closely with other institutions on mutually identified pest problems. This seems so reasonable that it is surprising that it has not been done more often.

Socioeconomic Approaches:

Crop protection research must have a socioeconomic perspective to be effective. This includes studies of issues such as sustainability, farming systems and other research approaches, as appropriate. In general, a more holistic approach to crop protection is needed.

Methodologies:

Methodologies are needed to allow extrapolation of research findings to other areas such as expected performance in other regions, predictions of pest population dynamics, etc. Presently, much of the information available to IARCs in the area of crop protection cannot be projected with much assurance to related situations. New methodologies in pest sampling, diagnostics, surveys and similar tools would greatly assist IARC research programs, and their partners in the national programs.

Communications:

Modern communications technologies (e.g., EMAIL, FAX) are needed to support crop protection research, training and technology transfer activities at IARCs.

Research Support:

Basic biological knowledge is essential to crop protection research activities. There are increasing needs for library services in crop protection. Library activity in the Centers need to be expanded for crop protection research, training, and technology transfer.

Site Specificity:

Biogeographic differences, climatic influences, topography and other biological realities presently constrain IARC crop protection research. This is compounded by phytosanitary restrictions. These restrictions must not be circumvented but they must somehow be accommodated through greater program flexibility. This could be done through better site selection to match biogeographic considerations with a sensitivity to the needs of agricultural production and public concerns.

Security:

Finally, increased urbanization around many IARC research farms is contributing to growing security problems that is sometimes manifested as theft or property destruction. This interferes with research activities and is a particularly tough problem for crop protection field studies as they often require expensive data loggers and similar equipment which are often lost without adequate security.

PROPOSED CHANGES

The panel identified a number of proposed changes in both policies and programs that would enhance crop protection research at the IARCs and strengthen their partnership activities. They are offered here for consideration.

Policy Changes:

Some of the policy changes suggested by the panel included topics for TAC, CGIAR and the Centers as well.

- o A clear statement should be made by the IARCs or the CGIAR on the appropriate use of all of the components of integrated crop protection, including pesticides.
- o "Off the top" budget should be used to support interdisciplinary research including intracenter, intercenter and interagency efforts.
- o Criteria are needed for judging the success of research, training and technology transfer programs in crop protection.
- o Special project funding for crop protection research should be given consideration as a way of targeting research activities of specific need.
- o Contract research (sensu CIP) with both public and private sector institutions should be considered as one way of getting specific crop protection research answers or specialized research services.
- o Each Center should assign a portion of one senior scientist's time to global issues in crop protection to encourage a broader perspective at each of the Centers.
- o Each Center should revise its mission statement to include a perspective on crop protection.
- o Each Center should consider establishing policy to foster a more holistic approach to crop protection problem solving through research, training and technology transfer.
- o The IARCs should give greater emphasis to crop protection training and crop protection technology transfer.
- o Centers should establish career paths for senior and professional staff with special emphasis given to attract scientific excellence.

Program Changes:

Some of the program changes suggested by the panel included ways to strengthen crop protection research at the Centers.

- o A system-wide crop protection program could be created to serve as a network for improved communication, coordination and collaboration with a designated champion to coordinate the various activities. The network would hold an annual conference on crop protection that might include an expanded attendance beyond the Center's to include partners, private industry, and perhaps others.
- o The proposed network would provide a mechanism for interinstitutional cooperation. It could also serve as a mechanism for the exchange of scientists and/or the rotation of crop protection specialists among Centers and partner institutions. Such a network could prove to be very effective for identifying desirable linkages between institutions and coupling those efforts with corresponding activities on a global scale. It was noted

that CIP already has a comparable network in place that is judged to be functioning quite effectively. The CIP model is worthy of more thorough study for its application to crop protection research.

- The panel members considered contract research a desirable way of acquiring specifically needed knowledge in areas of crop protection. Again, CIP is using contract research very effectively and this approach seems appropriate for applications in crop protection research.

- Some aspects of crop protection research support, such as bibliographic services, taxonomic identification and assistance in international shipments of biological materials, might best be provided through service contracts. Recognized authorities in these services such as CABI's Commonwealth Institute for Biological Control, the Consortium for Integrated Crop Protection and similar existing institutions could provide much needed assistance to IARC crop protection scientists, but they would need financial support for such services.

- A standardized mechanism should be created to provide external review teams for specific crop protection research projects. A more thorough and focused peer review for IARC crop protection scientists would be of significant benefit.

- IARC peer review panels for crop protection research should include some national program scientists. Representatives from national programs could also help the IARC scientists identify crop protection problems and hence they should be included in the research planning process.

- Consideration should be given to stationing some Center senior staff in national programs for defined periods of time and for special projects in crop protection.

- A mechanism should be developed to clearly define the objectives and limits to the number of crop protection projects to be undertaken, given the present limitation on human capital resources in the CGIAR system. Some of the current projects studied by the panel are stretched too thin for effective impacts.

- An effective method is needed to monitor, evaluate and document the impact of crop pests on global food security. This information would assist in the allocation of resources and the direction of research programs toward priority problems. Given the present limited numbers of senior scientists assigned to crop protection research, an effective mechanism for deciding which problems will be selected for attention has become particularly critical.

OPTIONS

After evaluating and discussing the issues, problems, constraints and needs of the IARCs for crop protection research, the panel developed the following three options for consideration:

- o An IARC Network for Crop Protection
- o A Crop Protection Center-Without-Walls
- o A Center for Crop Protection Research

A Network:

As proposed here, an IARC network with a leader and perhaps a small support staff would provide communication to the "key players" in the IARCs, to their partners and to their clients. The network would have the broad mission of facilitating crop protection research, training and technology transfer for appropriate clients. The network would do this by providing assistance and perhaps access to limited resources, as appropriate. An IARC Crop Protection Network would serve many of the IARCs needs for organization and coordination of crop protection research on a global basis.

The network would not be a funding agency for crop protection research per se, but would serve more in the role of facilitator and promoter. It would do this by identifying contacts, providing liaison and serving as coordinator for crop protection meetings. Support functions might include conferences and workshops, training programs and technology demonstration projects coordinated through the IARCs and other institutions.

The annual budget for the network would be quite modest, perhaps in the range of U.S. $600,000 to $800,000. The staff, in addition to the leader would be mostly clerical. Short-time consultants and shared appointments could be used for specific projects and activities.

A Center-Without-Walls:

The second option considered by the panel was to create a Crop Protection "Center-Without-Walls". A Center-Without-Walls would be a logical step beyond the concept of a crop protection network in that senior scientist staff would be employed by the "Center" but they would not be housed in a building complex at a single location. The senior scientists would be provided the freedom to move to the sites where they would serve most effectively.

Crop protection research, by its nature, requires activities to be conducted in certain areas and at specific times of year. A Center-Without-Walls would not be constrained by a physical plant at one or a few locations. It could be truly global and thereby take advantage of existing resources and opportunities to address specific pest problems as they arise.

In addition to the advantage of flexibility, a Center-Without-Walls would permit a continuous adjusting of research activities to supplement existing IARC programs. This would allow them to be fully compatible with existing research programs. A Center-Without-Walls working in crop protection would allow specialists to effectively interface with the breeding programs, while developing new and appropriate technology to supplement technical advances in Integrated Crop Protection. It would allow specifically focused networking of projects to do research and to solve problems at the farm level through multiple links.

The staffing for a Crop Protection Center-Without-Walls should grow over a period of time to an optimum number of about 20 mixed discipline senior scientists. These scientists should have demonstrated professional competence and be of international recognition and reputation. The scientific staff of the Center might be located virtually anywhere in the world with the selected sites appropriate to their projects and to the Center-Without-Walls' mission. For instance some individuals may choose to have a portion of their time assignment at an institution of higher education in a developed country. They would travel from there to specific sites at designated times for specific

activities. Other Center staff might choose to be located at an International Center, but scheduled to work in a national program for specific periods on selected topics. This flexibility in assignments would be an essential aspect of a Center-Without-Walls by providing rich opportunities to address crop protection topics in ways not now possible.

The administrative structure for a Center-Without-Walls would resemble that of the network described above. It would have an officer-in-charge plus a small clerical and professional staff to service the needs of the scientists. Significant project support for individual project leaders would be necessary. Appropriate services for research, training and technology could be provided through contracts.

A project-based annual budgeting program could be used to develop personnel agreements for assignments for each scientist. Individual annual reports on accomplishments and plans for the subsequent year could be an effective administrative mechanism for research project oversight and direction.

Although some of the senior scientists at the Crop Protection Center-Without-Walls might be hired directly (perhaps on a five-year contract with annual review) others might be indirectly employed through a home institution through reimbursable agreements. Some of these agreements might be for 100% of a scientist's time. Other agreements might be for a smaller proportion of a person's time. Each agreement should be negotiated case-by-case between the Center-Without-Walls and the home institution. Reimbursable employment would provide the Center with staffing flexibility, and could prove to be a very attractive employment mechanism for some senior scientists that would not otherwise consider international employment.

A rough estimate of the annual cost of operating a Crop Protection Center-Without-Walls employing and supporting a senior staff of 20 scientists and providing overhead to participants/host institutions would be U.S. $10 million. This estimate includes direct administrative costs, salaries for senior scientists and support for individual research projects in crop protection. It also includes sufficient funds to reimburse the host institutions for some of the indirect costs (overhead) associated with project participation (see Box 1).

A Crop Protection Center-Without-Walls would be able to address many of the problems and constraints identified by the panel. It could establish policy to deal with the issues raised by the panel in its discussions. And it could provide the much needed collaboration with accountability for crop protection research, training and technology transfer for the CGIAR system, its partners and its clients (see Box 2).

International Center for Crop Protection Research:

The third option considered by the panel was the establishment of a fully fledged International Center for Crop Protection Research with an international mandate. Such a Center might be formed out of ICIPE or might be developed independently.

The mandate for an International Center for Crop Protection Research would necessarily stretch across commodities and regions. This would of course require negotiation with the existing Centers for firm agreements on responsibilities and assignments. This could prove problematic.

An International Center for Crop Protection Research would give heightened visibility to this important research area and would provide new opportunities to develop training and technology transfer programs in crop protection.

The administration and staffing structure of an International Center for Crop Protection Research would be similar to existing Centers with commodity or regional mandates. A staff of 20 to 30 senior scientists plus clerical, professional and maintenance staff would be required to operate the Center. Additionally, a tremendously large outreach program for research, training and technology transfer would be required to successfully meet the needs of the Center's crop protection activities. For this reason, it is anticipated that an annual budget for a fully operational International Center in Crop Protection Research would exceed U.S. $25 million.

The advantages of designating an International Center for Crop Protection Research would be seen as heightened visibility for programs and a concentration of efforts. But these advantages would be partially off-set by difficulties in interfacing with existing programs at other IARCs. Collaborative projects would likely be difficult and overlapping missions would become complicated in some situations. The recruitment and retention of senior scientists might also be a continuing problem.

BOX 1

CROP PROTECTION

CENTER-WITHOUT-WALLS

Sample Budget

20 Senior Scientists @ $250,000/yr. (Includes salaries, benefits, technical support, travel, equipment, etc., but does not include overhead costs which would be paid directly to the host institutions (at a negotiated rate) to provide needed services, space and support for research activities)	$5,000,000
Overhead to Host Institutions @ $50,000/ scientist year.	$1,000,000
Grants and Contracts.	$3,500,000
Center Administration and Management (includes conferences, workshops, and clerical services for center).	$500,000
TOTAL	$10,000,000

BOX 2

CROP PROTECTION
CENTER-WITHOUT-WALLS

Example Project

The following example has been developed to describe how a single project in the Center-Without-Walls might be organized.

A senior scientist is employed by the Center on a 5 year (annual, renewable on merit review) research project to investigate and develop components of an IPM program for maize. The work time- table the first year includes six months at CIMMYT in Mexico to develop the targeted pest problems, evaluate germplasm with CIMMYT scientists and review tropical maize production practices as they impact crop protection. Two months are then allocated for laboratory and literature research at CABI's Commonwealth Institute for Biological Control in Ascot, England and to plan a collection trip for biological control agents in appropriate locations in South America. The collection trip is then the final four months of the first year.

The costs of supporting the activities are directly reimbursed to the host institutions (CIMMYT and CABI) as indirect costs (overhead).

The second year timetable includes 4 months at a research laboratory cataloging and storing the biological collection for future needs. This might be at a university where facilities, space and scientific support is readily available for the tasks.

The next 8 months would be spent back at CIMMYT conducting field tests of biological activity with selected isolates. International movement of the agents would be facilitated by the network of support already formed (CABI and the university).

The third year would focus on integrating the biological control tactics with the major production practices. This might be at IITA, in West Africa if that location was chosen as most suitable.

Thus, this sequence of research follows the normal progression of investigation, expansion and integration with a mix of Centers, research institutions and locations, each facilitating research activities at key times. The opportunities to interact with all crop disciplines is a big plus and the flexibility to move to the next step at the appropriate location is a unique advantage of the Center-Without-Walls concept.

As certain needs arise (research topics) or opportunities present themselves (training, workshops) the Center would provide support as grants, contracts or other resources to enhance and facilitate project activities.

CONCLUSIONS

The proposed network of crop protection activities would go a long way in meeting the needs identified by the panel for crop protection activities in the CGIAR system. However, the panel felt strongly that more, if not all, of the proposed changes would be better and more completely addressed through the establishment of a Crop Protection Center-Without-Walls. Such a Center would provide programmatic flexibility to a degree not possible with a fixed location research Center. This is an important consideration for an institution charged with global responsibilities in research, training and technology transfer. A Center-Without-Walls would be an excellent way to provide needed leadership in crop protection, resolve the need for accountability, provide needed coordination of activities through planning and communication and assist in the development of policy impacting crop protection. It is for these reasons that the following recommendations are offered for further evaluation.

RECOMMENDATIONS

It is recommended that:

- The Consultative Group on International Agricultural Research establish a network of IARC crop protection specialists. The network would have the purpose of strengthening research coordination, collaboration and communication in IARC crop protection. It is further recommended that this network of crop protection activities be encouraged to evolve into a Center-Without-Walls. The timetable for this transformation might be over a 5 year period, allowing it to "ramp up" with senior staff hiring and project planning in research, training and technology transfer.

- TAC consider fostering through the network an annual meeting of crop protection specialists from IARCs and partner institutions to promote communication and coordinated activities in crop protection research, training and technology transfer. A "summit meeting" would be a logical first step in establishing a network of crop protection scientists.

- Each International Center identify a crop protection coordinator to serve as a contact for individuals wishing to establish linkages in crop protection research, training and technology transfer.

- All Centers carefully review the emphasis now given to crop protection research as part of their on-going strategic planning process and provide senior scientists in crop protection opportunities to evaluate and plan new directions in crop protection research, training and technology transfer.

- TAC address the policy issues of crop protection research with a view to all of the components of Integrated Crop Protection. Special reference should be given to the appropriate use of pesticides in Integrated Pest Management programs in Third-World situations. A TAC evaluation should include not only the issues of pesticide safety and handling, but food safety, environmental impact and public perceptions of the uses of pesticides in contemporary agriculture.

ACKNOWLEDGEMENTS

The Study Director expresses his sincere appreciation to Dr. Robert Theberge for serving as a special consultant to this project. His assistance was enormously important to the effort. The Study Director is also grateful to Ms. Pamela Love for her able assistance as rapporteur for the Expert Panel meeting. He is also grateful for the excellent assistance provided to the project by the Staff of the CGIAR at World Bank in Washington, D.C. and particularly to Ms. Lenore Beacham for her extraordinary helpfulness. The Study Director is also most grateful to the Expert Panel members who provided rich perspectives, observations and advice on how to strengthen IARC crop protection research. Finally, he is most grateful for the word processing assistance of Mr. Thomas Phillips who most ably transcribed his rough dictation into workable documents.

The Study Director takes full responsibility for any errors or omissions contained in this document.

TABLES

Table 1. Summary evaluations of the crop protection research activities at CIAT. Evaluations were derived by consensus of the expert panel (see Appendix C for membership). Activities were scored on a scale of 0 to 4, with 0 being no activity and 4 being very high research activity. Sources of information for the judgment included first hand knowledge and various documents (see Appendix G).

RESEARCH ACTIVITIES	CASSAVA	FORAGES	PHASEOLUS BEANS	RICE
TACTICS				
Host Plant Resistance	2	3	4	4
Mechanical Control	0	0	0	0
Chemical Control	1	0	1	1
Cultural Control	0	0	0	1
Biological Control	2	0	1	0
IMPLEMENTATION				
Surveys	2	0	0	1
Monitoring	1	0	1	1
Forecasting	0	0	0	0
Loss Assessment	0	0	0	1
Economic Thresholds	1	0	1	1
METHODOLOGIES/SCIENCES				
Modeling	1	0	0	0
Population Dynamics	0	0	0	0
Biology/Ecology	1	1	2	1
APPROACHES				
IPM	1	0	3	2
Socioeconomics	1	0	1	1
Farming Systems	0	2	2	2
Animal Integration	0	0	3	0
Sustainable Development	0	0	0	0
TOTALS	**13**	**6**	**16**	**16**

Table 2. Summary evaluations of the crop protection research activities at CIMMYT. Evaluations were derived be consensus of the expert panel (see Appendix C for membership). Activities were scored on a scale of 0 to 4, with 0 being no activity and 4 being very high research activity. Sources of information for the judgments included first hand knowledge and various documents (see Appendix G.)

RESEARCH ACTIVITIES	BARLEY	MAIZE	WHEAT
TACTICS			
Host Plant Resistance	4	4	4
Mechanical Control	0	1	0
Chemical Control	1	1	2
Cultural Control	0	1	1
Biological Control	0	1	1
IMPLEMENTATION			
Surveys	1	1	3
Monitoring	0	1	3
Forecasting	0	0	1
Loss Assessment	0	0	1
Economic Thresholds	0	0	0
METHODOLOGIES/SCIENCES			
Modeling	0	0	0
Population Dynamics	0	0	0
Biology/Ecology	2	2	2
APPROACHES			
IPM	0	1	1
Socioeconomics	0	1	0
Farming Systems	0	1	0
Animal Integration	0	0	0
Sustainable Development	0	0	0
TOTALS	**8**	**15**	**19**

Table 3. Summary evaluations of the crop protection research activities at CIP. Evaluations were derived by consensus of the expert panel (see Appendix C for membership). Activities were scored on a scale of 0 to 4, with 0 being no activity and 4 being very high research activity. Sources of information for the judgments included first hand knowledge and various documents (see Appendix G).

RESEARCH ACTIVITIES	POTATO	SWEET POTATO*
TACTICS		
Host Plant Resistance	4	4
Mechanical Control	0	0
Chemical Control	2	1
Cultural Control	4	3
Biological Control	2	1
IMPLEMENTATION		
Surveys	3	2
Monitoring	3	2
Forecasting	1	0
Loss Assessment	1	1
Economic Thresholds	1	0
METHODOLOGIES/SCIENCES		
Modeling	1	0
Population Dynamics	1	0
Biology/Ecology	3	2
APPROACHES		
IPM	4	2
Socioeconomics	1	1
Farming Systems	0	1
Animal Integration	1	0
Sustainable Development	2	1
TOTALS	**34**	**21**

* IITA commodity recently transferred to CIP.

Table 4. Summary evaluations of the crop protection research activities at ICARDA. Evaluations were derived by consensus of the expert panel (See Appendix C for membership). Activities were scored on a scale of 0 to 4, with 0 being no activity and 4 being very high research activity. Sources of information for the judgments included first hand knowledge and various documents (See Appendix G).

RESEARCH ACTIVITIES	WHEAT	BARLEY	CHICK.& LENTILS	PIGEON PEA	FAVA BEAN	PASTURE
TACTICS						
Host Plant Resistance	4	4	4	4	4	3
Mechanical Control	0	0	0	0	0	0
Chemical Control	1	1	0	1	0	0
Cultural Control	3	1	2	2	2	0
Biological Control	1	0	0	0	0	0
IMPLEMENTATION						
Surveys	2	2	1	1	1	1
Monitoring	2	2	1	1	1	0
Forecasting	1	1	1	1	1	0
Loss Assessment	2	2	1	1	1	0
Economic Thresholds	1	1	0	0	0	0
METHODOLOGIES/SCIENCES						
Modeling	2	1	0	0	0	0
Population Dynamics	2	1	0	1	0	0
Biology/Ecology	2	1	0	0	0	0
APPROACHES						
IPM	3	3	3	3	3	3
Socioeconomics	1	1	1	1	1	1
Farming Systems	3	3	2	2	2	3
Animal Integration	0	0	0	0	0	2
Sustainable Development	2	2	2	2	2	3
TOTALS:	**32**	**26**	**18**	**20**	**18**	**16**

Table 5. Summary evaluations of the crop protection research activities at ICRISAT. Evaluations were derived by consensus of the expert panel (See Appendix C for membership). Activities were scored on a scale of 0 to 4, with 0 being no activity and 4 being very high research activity. Sources of information for the judgments included first hand knowledge and various documents (See Appendix G).

RESEARCH ACTIVITIES	CHICK PEA	GROUNDNUT	MILLET	PIGEON PEA	SORGHUM
TACTICS					
Host Plant Resistance	4	4	4	4	4
Mechanical Control	1	1	1	1	1
Chemical Control	1	3	1	1	1
Cultural Control	1	2	1	1	1
Biological Control	0	0	0	0	0
IMPLEMENTATION					
Surveys	0	0	1	0	1
Monitoring	0	0	0	0	0
Forecasting	0	0	0	0	0
Loss Assessment	0	0	1	0	1
Economic Thresholds	0	0	0	0	0
METHODOLOGIES/SCIENCES					
Modeling	0	1	0	0	0
Population Dynamics	1	1	1	1	1
Biology/Ecology	2	2	2	2	2
PPROACHES					
IM	2	2	2	2	2
Socioeconomics	1	1	1	1	1
Farming Systems	1	1	1	1	1
Animal Integration	0	0	0	0	0
Sustainable Development	2	2	0	2	2
TOTALS:	**16**	**20**	**16**	**16**	**18**

Table 6. Summary evaluations of the crop protection research activities at IITA. Evaluations were derived by consensus of the expert panel (See Appendix C for membership). Activities were scored on a scale of 0 to 4, with 0 being no activity and 4 being very high research activity. Sources of information for the judgments included first hand knowledge and various documents (See Appendix G).

RESEARCH ACTIVITIES	CASSAVA	MAIZE	PLANTAIN*	VIGNA	YAMS
TACTICS					
Host Plant Resistance	4	4	-	4	2
Mechanical Control	0	0	-	0	0
Chemical Control	0	1	-	1	1
Cultural Control	3	3	-	3	2
Biological Control	4	3	-	2	0
IMPLEMENTATION					
Surveys	4	2	-	1	0
Monitoring	4	1	-	1	0
Forecasting	1	0	-	0	0
Loss Assessment	4	1	-	2	0
Economic Thresholds	4	3	-	2	0
METHODOLOGIES/SCIENCES					
Modeling	3	0	-	0	0
Population Dynamics	2	1	-	2	0
Biology/Ecology	4	2	-	3	1
APPROACHES					
IPM	1	2	-	2	0
Socioeconomics	1	3	-	1	0
Farming Systems	3	3	-	1	0
Animal Integration	1	1	-	0	0
Sustainable Development	3	2	-	1	0
TOTALS:	**46**	**32**	-	**26**	**6**

* Newly introduced commodity crop - unable to assess.

Table 7. Summary evaluations of the crop protection research activities at IRRI. Evaluations were derived by consensus of the expert panel (see Appendix C for membership). Activities were scored on a scale of 0 to 4, with 0 being no activity and 4 being very high research activity. Sources of information for the judgments included first hand knowledge and various documents (see Appendix G).

RESEARCH ACTIVITIES	RICE
TACTICS	
Host Plant Resistance	4
Mechanical Control	1
Chemical Control	2
Cultural Control	2
Biological Control	2
IMPLEMENTATION	
Surveys	3
Monitoring	3
Forecasting	2
Loss Assessment	3
Economic Thresholds	3
METHODOLOGIES/SCIENCES	
Modeling	3
Population Dynamics	3
Biology/Ecology	4
APPROACHES	
IPM	2
Socioeconomics	2
Farming Systems	3
Animal Integration	0
Sustainable Development	1
TOTALS	**43**

Table 8. Summary evaluations of the crop protection research activities at WARDA. Evaluations were derived by consensus of the expert panel (see Appendix C for membership). Activities were scored on a scale of 0 to 4, with 0 being no activity and 4 being very high research activity. Sources of information for the judgments included first hand knowledge and various documents (see Appendix G).

RESEARCH ACTIVITIES	RICE*
TACTICS	
Host Plant Resistance	3
Mechanical Control	1
Chemical Control	1
Cultural Control	1
Biological Control	0
IMPLEMENTATION	
Surveys	2
Monitoring	2
Forecasting	0
Loss Assessment	1
Economic Thresholds	1
METHODOLOGIES/SCIENCES	
Modeling	0
Population Dynamics	0
Biology/Ecology	2
APPROACHES	
IPM	1
Socioeconomics	0
Farming Systems	2
Animal Integration	0
Sustainable Development	3
TOTALS	**20**

* Reflects work previously done at IITA.

Table 9. Expenditures of the International Agricultural Research Centers for crop protection research as a percent of the Center's total budget in U.S. dollars (see Appendix H for details).

CENTER	TOTAL BUDGET FY 1989 (x1000)	CROP PROTECTION BUDGET AS % OF TOTAL
CIAT	33,443	6.1
CIMMYT	35,521	6.0
CIP	21,788	7.6
ICARDA	27,444	6.7
ICRISAT	32,122	12.2
IITA*	-	-
IRRI**	30,838	6.4
WARDA	6,830	8.8

* Cannot be computed from information provided
** FY 1990

Table 10. United States of America's public sector research expenditures and scientist years (SY) for Fiscal Year 1987-88 for crop protection research. Information is expressed as a percentage of all plant science support in the public sector*. (See Appendix I for details.)

CROP PROTECTION RESEARCH ALLOCATIONS

	EXPENDITURES %	SY %
Insects, etc.	10.8	11.5
Diseases & Nematodes	14.5	15.5
Weeds	5.0	4.7
TOTAL	30.3	31.7

* Data includes agronomic and horticultural commodities but does not include forest species.

Source: Current Research Information Service, CSRS, U.S. Department of Agriculture, National Agricultural Library. Beltsville, Maryland.

APPENDICES

APPENDIX A

OUTLINE

CROP PROTECTION RESEARCH
AN EVALUATION STUDY
PREPARED FOR
THE TECHNICAL ADVISORY COMMITTEE
CONSULTANT GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

I. Introduction

A. Production constraints and needs for crop protection research

This section will define the general domain of crop pests[1] as biotic stresses important to agricultural production. It will look at the issue of farm profitability and the alternatives for crop protection as a cost of control. It will also look at the sustainability of agricultural production systems and the mounting concerns for the safe and justified use of pesticides in crop production and in the food consumed.[2]

B. Historical perspectives on crop protection

This section will develop the evolving philosophy of integrated crop protection and describe advances in pest management research pertinent to the mission of International Agricultural Research Centers (IARC). It will highlight some of the recognized constraints and limitations of integrated crop protection research as those items relate to the interests of the CGIAR.

C. Contributions of the IARC's to crop protection

The positive, successful research contributions of the IARC's will be reviewed along with selected noteworthy examples.

II. Technical concepts

A. Components of crop protection

The four components of crop protection have been identified as 1) mechanical; 2) chemical; 3) cultural; and 4) biological practices that can be used to control and/or manage crop pests. Descriptive examples will be given along with supporting statistics on current pest control practices used in global and regional agricultural production.

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[1] "Pests" and "pests and diseases" are used interchangibly in this text as inclusive terms for biotic agents causing stress to economically important crops. Examples include insect pests, pathogenic fungi, nematodes, bacteria, viruses, etc.

[2] Because of time constraints and data limitations this proposed review will not be able to undertake a full analysis of national crop protection research activities related to the International Agricultural Research Centers, except through information found in IARC strategic plans and other available documents.

B. Philosophy of integrated pest management strategies

This section will spell out some of the accepted principles of pest science and will develop statements on needed basic biological knowledge in areas such as:

- o genetics of the host-pest interaction
- o ecological concepts and principles
- o host-pest population dynamics
- o pest management decision theory
- o information delivery systems
- o technology transfer

This section will also deal analytically with the topic of interdisciplinary research as an important component of integrated strategies for pest management. The benefits of the present organization of the IARC's will be weighed against programmatic issues that have been discussed both within and external to the IARC's. Factors that impact crop protection research (e.g. research site specificity) will be elaborated with examples.

C. Current pest control problems

Many items have been identified as constraints to developing integrated pest control strategies. Problems such as pest and pathogen variation compromising host-plant resistance, pest and pathogen resistance to pesticides, environmental pollution from agricultural chemical use, human health hazards from pesticides, loss of germ plasm resources and poor documentation of crop losses will be dealt with in this section.

D. Current research constraints

The often identified difficulties of site specificity for research pest management and the problems of uniqueness by commodity and by pest will be detailed. Concepts of experiment design, such as scope and scale of the experiment, and the necessity for quantitative measurements will be specified. The needs for flexibility of investigation and regional specificity (especially for the tropics) will be elaborated with examples appropriate to the IARC's. International difficulties, such as seed health quarantine, and other considerations will be dealt with in detail. Finally comparative advantages of alternative research approaches will be evaluated.

Discussion will also be provided on perceived problems of integrated crop protection with a forward-looking view on topics such as the protection of intellectual property resulting from biological control research discoveries. The governmental regulation of articles and products; the biosafety of research activities; and the continuing problem of storage and distribution of items such as chemicals and biologicals as components of an integrated crop protection system will be discussed.

III. Research Agenda

A. Current needs for research

Presently, much of the underlying theory and many of the methods for pest management research are either inadequate or need to be developed. This section will specify research needs in basic biology (including biotechnology) and system science research in areas such as climatology, meteorology, and modeling the movement dispersal of pests. The agricultural validity of existing biological and environmental models will also be discussed. The relation of these emerging models to crop and yield loss models (including type and amount of loss) will be developed. Finally, research topics in areas such as seed health, quarantine, diagnostics, pest and disease forecasting and other elements of a robust crop protection research program will be detailed.

The resources and manpower needed to continue development of crop protection research appropriate to the mission of the International Agricultural Research Centers will be outlined. This will be done through an evaluation by commodity of the comparative advantages of existing research efforts and apparent overlaps and gaps in activities in the CG network, as well as non-associated centers.

B. New technologies opportunities

Recent advances in biotechnology and high technology (e.g. computers) offer exciting applications in pest management. Biotechnology offers promise for vastly improved host plant resistance, biological control of insect pests and diseases and the diagnosis of biotic agents with extreme specificity. High technology has exciting applications in the area of pest and disease forecasting, information exchange, resource planning and many other applications. These topic areas will be detailed within this section.

C. Current resource allocations and future needs

An evaluation of present research activities related to crop protection will be undertaken using existing documentations. Projected research needs will also be presented to assist in setting out expectations and opportunities.

D. Policy issues

The new technology will bring with it policy issues of importance to the IARC's. Some examples of these policy issues include the risk of research activities, including biosafety concerns and the potential impacts of the technology on the environment, economy, social systems and ethical values. There are expected to be enormous problems sorting out the intellectual property rights of discoveries along with substantial difficulties with technology transfer in less developed economies. The cost and availability of the new technology will continue to be a policy issue worthy of attention. This section will develop opposing arguments of these issues as they relate to expected research discoveries in crop protection and the mission of the IARC's.

IV. Programmatic options

A. Pest management research options for the IARC's

This section will detail six options available to individual IARC's that would facilitate specific activities in pest management research. These options will be elaborated to include:

- o programmatic restructuring within centers
- o contracting research for identified problems
- o the concept of regional research centers
- o designated lead centers and targeted areas for research
- o project funding from new or existing center resources
- o institutional collaboration (e.g. with national programs)

Combinations of the above options will be explored using specific examples.

B. Options for CGIAR/TAC

Several options will be developed in this section as CGIAR/TAC choices for crop protection research at IARC's or other institution. These include:

- o create/adopt one or more new centers to specialize in crop protection research
- o create a network of crop protection scientists within the existing IARC system
- o provide special grants to Center scientists for targeted research in pest management/crop protection
- o develop a competitive grants program in crop protection for Center scientists
- o establish a technical secretariat to identify problems, establish a research network, periodically conduct critical reviews of research activities and to offer solutions and assign resources consistent with a defined mission in crop protection/pest management.

Several of these options offer unique opportunities for funding from institutions such as multinational corporations, environmental groups or government agencies (e.g.US EPA). Such sources of research funding can now identify with the components of integrated crop protection research as they are consistent with their interests and purposes. This section would develop examples to point out ways in which this approach might be developed.

V. Appendices

Several appendices would be included containing information supportive of the report and to help document topics, activities, and needs.

SUGGESTED ACTIVITIES

It is proposed that the above sections be developed into a draft report for review by TAC. Once the revised report is approved by TAC it would be distributed to one or two senior crop protection research scientist from each of the Centers of the IARC system and to scientists at selected associated research centers and/or institutions as appropriate. Those individual scientists would be invited to participate in a three day workshop to identify needed research activities, and to develop a plan-of-action for crop protection research for the IARC network. The Center representatives would also be asked to provide analytical evaluations of present activities to be used in developing the plan-of-action. The complete plan-of-action would then be submitted to TAC for consideration.

David R. MacKenzie, Director
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901 "D" Street S.W.
Washington, D.C. 20251-2200
(202) 447-5741
March, 1989

APPENDIX B

April 19,1989

Dr. John Monyo
Executive Secretary, TAC
FAO, Rome
Facsimile Letter

Dear John:

I am FAXing to you the completed report on Phase I of the Crop Protection Study. I hope you are satisfied with the report as submitted. Please let me know your reaction. A copy is also being sent via courier.

I'm now begining Phase II of the study. The World Bank contract has been issued and all goes well with that aspect of the study.

Best wishes,

Sincerely,

Dave

David R. MacKenzie
Director, NBIAP

RESTRICTED

TAC EYES ONLY

Study on Crop Protection Research

at

International Agricultural Research Centers

Phase I Report

Commissioned by the

Technical Advisory Committee

The Consultative Group on International Agricultural Research

David R. MacKenzie
April 1989
Washington, D.C.

TABLE OF CONTENTS

PREFACE

The Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) has commissioned this study of crop protection research activities at the International Agricultural Research Centers (IARC). This is the first report of three covering a three-phased evaluation, analysis, and recommendation to the TAC.

The purpose of dividing the study into three phases was to accommodate other TAC planning activities and meetings while permitting broader input into the study from diverse sources.

The importance of crop protection research to the missions of the International Agricultural Research Centers is enormous. The delicate balancing of priorities against limited resources and tremendous responsibilities is a difficult task. In spite of these constraints, the IARC's have made major research contributions in the area of crop protection and those contributions are appreciated globally.

This is an appropriate time for the Centers to reassess their accepted priorities' given their current extensive activities in strategic planning, the recent emergence of strong National Agricultural Research Systems (NARS) in agricultural research and the growing global concerns for the sustainability of the major agricultural production systems.

The research opportunities identified for crop protection must be judged against realistic assessments of the available theory, knowledge and the likelihood for practical applications to real world problems. This Phase I report will attempt this evaluation with the understanding that the judgments will be subjected to responses, corrections and restatements in a Phase II effort to better serve the best interest of science, the International Centers, their partners and their clients.

CONCEPTS IN CROP PROTECTION

The complexity of most biological systems has been a scientifically well-established fact for many decades. This appreciation has grown as a consequence of research that has repeatedly demonstrated the capacity of living organisms to respond to changing conditions and to new opportunities. This understanding has been applied in the development of solution to problems in production agriculture by recognizing that in many instances, a single tactic for a complex problem may prove to be inadequate.

This axiom has proven all too true for agricultural crop protection. Reliance on a single control factor, such as host plant resistance, chemical sprays or other singular activities underlies some of the major failings recorded for crop protection. The capacity for genetic variability within biotic agent species has been repeatedly demonstrated as a biological fact, and an economic reality.

Appendix I of this report elaborates some of the details in the historical development of crop protection in agriculture that have led to the present reliance on certain approaches to crop protection. In this section information is developed on the conceptual components of integrated crop protection along with some of the reasons why research on these topics is making major changes in research directions and programmatic emphasis.

Crop protection is made up of classes of activities that can be, for editorial purposes, divided into:

* mechanical
* chemical
* cultural
* biological

Mechanical practices in crop protection are best exemplified by the cultivation of weeds, ploughing to bury crop residues that may harbor pest, and similar practices common to agriculture that are intended to reduce the amount or numbers of biotic agents.

Chemical protection practices are well-known to agriculture, especially the use of pesticides, which retard or kill biotic agents. Herbicides are commonly used in production agriculture to control weeds. Insecticides, fungicides, antibiotics and similar chemical substances are also used against targeted biotic agents. Fertilizers can also affect the susceptibility or resistance of a crop and in that vein, they also serve as a chemical protection practice by adjusting the quantity of fertilizer applied to the crop. Thus, chemical control may be direct or indirect and related to other crop management practices.

Cultural practices can also be used to protect crops from biotic agents. The timing of a planting, adjustments in plant spacing, and similar management practices can contribute significantly to the development and consequent impacts of biotic

agents on a crop production systems.

Biological practices may also significantly affect crop protection and represent important pest management strategies for commercial agriculture. Included in this category are host plant resistance (including strategies to deploy genes for resistance), the use of biological control agents, and similar strategies.

The growing concern for the sustainability of agricultural productions systems, the evidence for the excessive use of some pesticides, and the growing cost of crop production systems that often leave farmers with little or no profit, have caused re-evaluation of how to mix and match the components of crop protection. These are, of course, all within the domaine of integrated crop management. Crop protection research should not be considered in isolation from crop management.

The concept of Low Input Sustainable Agriculture (LISA) is an important issue which is directly related to these considerations and concerns. The philosophical approach of LISA is to greatly reduce agriculture's dependency on chemicals by selecting those approaches that would yield a long term, environmentally stable agricultural production system that would be sustained for future generations.

More traditional crop protection researchers have approached their responsibilities from a different direction which is, perhaps, best exemplified by Integrated Pest Management (IPM). The IPM strategy is to mix component activities for a more dependable crop protection system. The proper mix of components depends on biological and economic choices based on a thorough understanding of the dynamics of the system and the likelihood of future developments such as weather changes, pest movements and similar information.

IPM and LISA are philosophically at odds. Underlying the current debate is the question of how best to provide adequate and dependable crop protection. The significant difference in the two approaches is the degree of acceptance of agricultural chemicals in the final mix. There is no argument between the two groups over the desirability of integrating multiple practices. The issue is, when and how much chemical control to use.

This is a significant consideration for the International Agriculture Research Centers inasmuch as there must be a balance between scientific need and public acceptance of the research approach. Some Centers are said to reluctantly accept modest research funding from multi-national chemical companies, while others reject such support in any form whatsoever.

This dilemma is a critical issue for crop protection research in the International Agriculture Research Centers. And it has for too long gone unaddressed. The primary dependence of the IARC's on host plant resistance, their modest contributions to research on cultural control methods, and the relative infancy of biological control research have further contributed to the present situation. Some Center programs have overcome these limitations out of necessity and or by design.

Other crop protection problems have gone less than completely addressed. Meanwhile the global use of pesticides accelerates in commercial rice production and without much attention by the IARC's to the alternatives to this pesticide use. For instance, the expense of pesticides in Latin American rice production are now typically 20% or more of the cost of production (R. Zeigler, personal communication).

Now is the time for the IARC's to thoroughly reevaluate this situation for all crops and begin to make new decisions on how best to approach crop protection research. The emergence of biological control as a bio-rational method for crop protection is exciting and definitely warrants research attention. A new understanding is also emerging on the value of cultural control methods representing more than just the old ways of agricultural production. The opportunities in biotechnology to genetically engineer more durable host plant resistance, or novel biological control agents are other new and exciting avenues in crop protection research. How will chemical control practices fit into this new crop protection matrix? How will the International Agricultural Research Centers participate in designing these integrated crop protection systems?

This Phase I report explores these questions by looking at current activities and possible research opportunities that should be considered by individual IARC's through a reprioritization of efforts, re-programming of projects, and a re-thinking current policies.

STUDY PLAN

As mentioned previously, this study has been divided into three phases. Phase I offers preliminary evaluations of the ongoing research activities in crop protection by IARC's. These evaluations consider individual Center mandates, current research activities, strategic planning proposals and some of the related policy issues.

The Phase II report will be derived from a workshop of agricultural scientists selected for their experience through past employment at one or more International Agricultural Research Center and by their scientific discipline in crop protection. The workshop will be convened for a two day period. It will use the highly structured group meeting methods of Andre Delbecq which he terms the Nominal Group Technique. This procedure will be used to extract multiple items in response to specifically targeted questions regarding agricultural crop protection research at International Agricultural Research Centers. It will then build by consensus some recommendations for continuing and/or for changing various crop protection research programs at the IARC's.

The Phase III of the study will also be a workshop. It will be an open forum to allow responses by senior scientist currently employed as crop protection specialists at International Agricultural Research Centers. These discussions will be scientific and programmatic responses to the early recommendations presented in Phase I and Phase II of this study. The timetable calls for completion of Phase I by the end of April, 1989. Phase II will be completed by the end of July, 1989. Phase III will be completed by the end of September 1989. This three phase approach to this study should permit critical scientific evaluation balanced with realistic research expectations.

SOURCES OF INPUT FOR PHASE I

The evaluations and conclusions presented in this Phase I report have been derived from multiple sources. The CGIAR Library was of tremendous assistance in providing annual reports, strategic plans and related documents for review and analysis. The TAC secretariat provided several important studies including the 1982 Crop Protection Document prepared for TAC.

Direct involvement of the author in several recent planning programs at IARC's has also contributed useful information. The author served as a CIMMYT External Program Review panel member in 1988. On that assignment he travelled throughout Latin America, attended a CIMMYT Board of Trustees meeting and spent three weeks in August reviewing CIMMYT research programs and preparing the panel's report. In April 1989 the author served as a CIAT panel member to review the rice research program at that Center. He also served as an author and consultant in crop protection to the 1985 Anderson study entitled "International Agricultural Research Centers: Achievements and Potentials."

Additional information was derived from direct interviews conducted with several International Agricultural Research Center staff and ex-staff members. This was useful in gathering opinions and views on crop protection research at the various Centers. Other sources of information included the author's membership on the FAO Panel of Experts on Crop Protection; ongoing study of scientific reports of research in professional journals and more critical semi-technical treatments of IARC research (e.g. Bruce Jennings).

IARC CROP PROTECTION RESEARCH ACTIVITIES

Table 1 presents summary information on Center research activities by commodity. Inspection of Table 1 shows the existence of some overlaps between "mandates" that are often further complicated by "geographic mandates." These accepted assignments of research responsibilities are said to contribute a portion of the problem of identifying and coordinating some research areas. This is particularly true for crop protection research.

Table 2 presents aggregate subjective evaluations on crop protection research activities by the components of crop protection. The crop protection components were adapted from the Anderson study (cited above) with the recognition that other divisions of crop protection research could have been made, but these seemed suitable for this study. The evaluations of the level of research activity for the crop groupings range on a scale of 0 to 4 (with 4 representing very high levels of research activity.) When no information is presented in the table, that particular item is still under evaluation. These preliminary evaluations will be reviewed by the participants in the Phase II workshop and the final evaluations will be included in the Phase III report to TAC.

Many of the Centers have earned high marks for their significant contributions to the enhancement of host plant resistance through crop improvement. Several of the Centers have also given tremendous energies to pest surveillance projects through mechanisms such as international nurseries, trap nurseries, and similar approaches. Some very significant activities in integrated pest management are also well recognized. Some progress in biological control is also noted.

The International Centers should be rightfully proud of the research contributions that they have made to crop protection through past efforts and ongoing research.

More difficult to evaluate are the indirect contributions of IARC's as partners with National Agricultural Research Systems (NARS). It can be asserted that the IARC's have not received justifiable recognitions for the many contributions they have made through their NARS partnerships. This is a recognized weakness of the information in Table 2 and this fact must be noted.

The overlapping responsibilities for crop protection research by IARC's can best be exemplified by selecting one commodity for more indepth study. For this purpose rice research, as conducted at the various Centers, will be used as the demonstration example.

Four international Centers presently assert their responsibilities for rice research. These Centers are: International Rice Research Institute (IRRI), International Center for Tropical Agriculture (CIAT), the West African Rice Development Association (WARDA), and the International Institute

for Tropical Agriculture (IITA). IITA responsibilities will, over the next several years, be transferred to the WARDA program (to be completed 1991) and IITA will collaborate with WARDA on resource and crop management research. IITA will also continue to collect and preserve genetic resources of rice in Africa and "conduct pre-breeding research on African rice".

The participating Centers have obviously overlapping interests and responsibilities. In some cases, coordination seems to be lacking as demonstrated in the WARDA's "Strategic Plan: 1990 - 2000." The plan identifies on page 42 mostly "specific complementary activities" with IRRI and virtually "no direct activity" with CIAT or IITA. Given the announced disengagement of IITA from rice research, this may prove reasonable. However, given CIAT's Strategic Plan (now in draft form) which gives emphasis to high-rainfall savanna rice, IARC research in rice production and especially crop protection needs better inter-Center coordination.

Rice has also been targeted by TAC as one of the commodities for reduced resource allocations in the future. The announced decision will likely contribute to increased levels of competition between the Centers for limited resources for rice research. This may especially impact crop protection research in rice particularly when viewed as traditional research activities, vis a vis the need for new research initiatives in crop protection. This expected shortfall in resources is reflected in some of the IARC current strategic plans and has apparently contributed to programmatic decisions that will work to the disadvantage of crop protection research in rice.

The implications for overlapping responsibilities for commodities and/or geographic region is differentially significant for some areas of IARC research. Efforts by some of the Centers to negotiate memoranda of agreement (e.g., CIMMYT and IITA; CIMMYT and ICARDA) have met with mixed success. At issue in resolving these understandings are the complexities of crop protection research which often get lost in the documents which tend to focus on general aspects of crop improvement and germ plasm distribution. As noted above, this is only a portion of the domaine of crop protection research.

Another programmatic factor must be also considered. Discipline research in crop protection tends to become isolated and fragmented when it is a component of a plant breeding program. "Upstream" research in areas such as biological control, cultural practices, and similar crop protection studies are said to have met with limited acceptance at the IARC's. In some cases such research efforts have faced open discouragement by the leadership in commodity research programs. There is a big challenge for the Centers to redefine the dimensions of crop protection in light of new directions in research, an ever expanding horizon for technology and in to response to newly recognized environmental, economic and social responsibilities.

IDENTIFIED NEEDS

An analysis of the on-going crop protection research at the IARC's has identified areas of needs that should be addressed. This section identifies those needs in the following categories:

* research
* programmatic
* policy

The IARC's would benefit collectively by increasing research efforts in biological and cultural methods of crop protection. Particular research emphasis should be given to biological control and host plant resistance through increased efforts allocated especially through biotechnology. It is truly unfortunate that so little biological control research has been conducted that is appropriate to the tropics. The diversity of tropical organisms and the opportunities to assess attributes such as antagonism, competition and similar traits useful to biocontrol agents easily justifies significant increases in such research efforts.

Major portions of this research will be truly "ground breaking" inasmuch as new knowledge will be needed to develop viable commercial practices. This task would seem to be an appropriate responsibility for the IARC's. Many of the Centers profess throughout their strategic plans a desire to move their research efforts "up-stream", to conduct more strategic research. The alternative is to place greater reliance on developed countries such as the U.S., Japan, or the European countries to produce the needed crop protection technology appropriate to tropical agriculture. This approach seems to be flawed. The protection of intellectual property derived from biological research in more developed economies may mean that the discoveries may not be shared with developing economies, or only at a price.

Dependence on NARS's to develop biological and cultural control technology for crop protection also seems unwise. The complexity of the researchable problems and the long term nature of this type of research weighs against relying on NARS's. Thus, the IARC's are squarely at center-stage in the expectations for strategic research in crop protection for the tropics.

A second crop protection research need of the IARC's is in the area of technology transfer. Technology transfer as a mechanism for the IARC's is not well-developed and this deficiency needs to be researched. The expected (and planned for) shifts of the IARC's away from plant breeding (and hence improved seed distribution) to knowledge dissemination and the handling of biological agents is a far more complex task. New technologies will require new approaches to an extension systems that must be developed through direct research investments. This

need will become critical to the success of new crop protection technology inasmuch as to be useful. The technology must be extended to production agriculture. Surprisingly, this issue is treated incompletely in most of the IARC's strategic plans, but remains a major concern.

Programmatic deficiencies in crop protection research are also evident by studying the IARC's strategic plans and annual reports. The planning process for research in crop protection is often lost in the broader program issues of a Center. The Centers with programs for multiple commodities rarely if ever look longitudinally at crop protection across commodities. Most often they give preference to commodity programs at the expense of a discipline topic such as crop protection. This has had the undesirable effect of splintering a Center's efforts in crop protection which would otherwise benefit from indepth, coordinated planning of its discipline research efforts.

Related to this observation, are the consequences of research programs structures and the distribution of support (including funding) by commodity rather by research objective, identified problem, or specific research need. The allocation resources within the Center is, of course, traditionally the prerogative of the Center's administration. However, the assignment of resources to a commodity program may have the effect of lessening some of the opportunities for crop protection research.

The commodity program structures within the Centers may also lessen the chances for identified research leadership in crop protection research, not only within the IARC system but with the NARS's as well. To give greater emphasis and visibility to crop protection research within the IARC's would require significant programmatic readjustment to allow the development of strong crop protection research program leadership. If encouraged, this would facilitate better communication between Centers and with the national program partnerships. It would also greatly improve research linkages with institutions in developed countries. This would yield many direct and indirect benefits for the Center's research programs.

There are policy needs that should be addressed by individual IARC's that would work to facilitate new approaches to crop protection research. Primary among these is the need for a clearer definition of the mandates (and directions of research) between the Centers and better clarification of responsibilities with partner NARS's. In many of the current IARC strategic plans, crop protection research becomes a lost entity, homogenized into various commodity research programs. By directly addressing crop protection research needs, by setting out intended objectives, and by giving clear statements of policy to the Center scientists, their collaborators, colleagues and critics, all would know better where they intend to go and what they intend to accomplish in crop protection research.

Finally, it is imperative that a decision be made, either collectively or individually by the IARC's on the appropriate (or

inappropriate) role of agricultural chemicals as a tool in crop protection. Avoidance of the policy issue has left open the arguments from both supporters and critics of the IARC's. And this does not well serve the good interest of any of the Centers.

PHASE II ACTIVITIES

The next step in this evaluation study will be to assemble a panel of scientific experts with past International Agricultural Research Center employment experience to review historical and current problems in crop protection for the IARC commodities and to lay out the current needs for research on those problems. A two day workshop with approximately ten participants (see Appendix 3) will address the general problems common to all commodities (e.g. instability of host plant resistance, pest resistance to pesticides, crop loss documentation, germ plasm preservation). Attention will also be given to current research constraints in crop protection (i.e. site specificity, experimental design flexibility, needed quantitative methods for experimentation). The problems and constraints of crop protection research will be then addressed by the workshop. Some of these topics include manpower needs; requirements for fundamental knowledge in basic biology and biotechnology; systems research; climatology and meteorology; biological monitoring techniques; and seed health/quarantine considerations. The necessary resources (budget) to conduct this research to obtain the needed knowledge will be evaluated.

Other topics of interest that are indirectly related to crop protection will also be discussed. These will include the safety of experimentation with certain biologics (e.g. the importation of plant pests for research purposes) and the environmental, economic, social and ethical impacts of crop protection technology and how these might be assessed. The Phase II participants will also take a look at issues in intellectual property protection as they may affect the availability of technology and germ plasm useful to IARC and NARS crop protection research.

However, the primary assignment for the Phase II workshop participants will be to study the options for the IARC's wishing to expand crop protection research. Some of the topics likely to be discussed include the internal restructuring of programs (e.g. create departments); expand activities in contract research; developing "regional research projects" with sister institutions and/or NARS's; negotiate memoranda of understanding to establish designated lead centers for targeted research topics; identify and designate funding for crop protection research; and somehow establish a broader network for collaboration in crop protection research.

To accomplish one or more of the above items will require some choices among the alternatives. To initiate this discussion for the Phase II workshop participants, the following list of proposed choices will be presented to stimulate additional alternatives and begin exploration of the consequences of making certain choices. The tentative list of choices includes:

* Programmatic Restructuring
* A New Research Management Plan
* Directed Funding as:
  --Special Grants
  --Formula Funding
  --Designated Research Appointments
* Quasi-competitive Grants Program
* Informational networking for targeted disciplines
* Creating or Restructuring a Center for Crop Protection
* Establish a Secretariat on Crop Protection

When the Phase II document has been prepared (early August, 1989) an invitation will be extended to the Directors General of the appropriate IARC's. The invitation will ask for representative Center senior staff scientists to attend the Phase III workshop. This effort will initiate the drafting of the Phase III document that will:

* Verify earlier evaluations of IARC research activities in crop protection.
* Provide verification of specific examples of IARC accomplishments in crop protection.
* Develop specific needs statements for future crop protection records.
* Formulate specific activities to enhance crop protection research efforts.
* Proposed structural changes to programs and policy changes for Centers that would facilitate crop protection research.

This phase of the study will be completed by October 1, 1989.

APPENDIX 1

This century has witnessed some very significant changes in crop cultivation practices. New technologies have been developed in ways to replace labor. These changes have come as new varieties, mechanization, and chemicals which have all contributed to increased crop production. Farmers today use far less labor than their parents or grandparents to produce a crop. The following data are the hours of labor required in the years 1915, 1950 and 1985 in the United States to produce 1 unit of selected crop commodities. (Source: United States Department of Agriculture Statistics, 1986. U.S. Government Printing Office: Washington, D.C., p. 395)

	YEAR		
Commodity	1915	1959	1985
corn*	132	53	3
wheat*	98	34	7
soybean*	143	41	12
potato**	26	12	3
cotton***	299	146	6

* = 100 bu; ** = 1 ton; *** = 1 bale.

The reduction in labor in U.S. farming this century is striking and similar patterns can be found throughout the world.

The substitution of mechanical and chemical cultivation practices for labor is now being closely scrutinized as many types of farming systems appear not profitable and some others are seen as not sustainable. This century has witnessed tremendous surges in mechanical and chemical cultivation practices that have not been paralleled with new technology in cultural and biological control practices.

Agricultural researchers are now looking to develop new technology that will make use of the new biological knowledge for a more rational and profitable system of integrated practices for better protection of crops.

APPENDIX 2

CGIAR-supported International Agricultural Research Centers

CIAT	Centro Internacional de Agricultura Tropical, Cali, Colombia.
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo, El Batan, Mexico.
CIP	Centro Internacional de la Papa, Lima, Peru.
IBPGR	International Board for Plant Genetic Resources, Rome, Italy.
ICARDA	International Center for Agricultural Research in the Dry Areas, Aleppo, Syria.
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India.
IFPRI	International Food Policy Research Institute, Washington, D.C., United States of America.
IITA	International Institute of Tropical Agriculture, Ibadan, Nigeria.
ILCA	International Livestock Center for Africa, Addis Ababa, Ethiopia.
ILRAD	International Laboratory for Research on Animal Diseases, Nairobi, Kenya.
IRRI	International Rice Research Institute, Los Banos, Philippines.
ISNAR	International Service for National Agricultural Research, The Hague, Netherlands.
WARDA	West Africa Rice Development Association, Bouake, Cote d'Ivoire.

APPENDIX 3

Proposed Phase II Workshop Participants*

Name	Disciplinary Experience	Institutional Experience
1. E. Heinrichs	Entomology	IRRI
2. M. Shepard	Entomology	IRRI
3. P. Teng	Pathology	IRRI
4. R. Theberge	Pathology	IITA
5. R. Williams	Pathology	IITA, ICRISAT
6. H. Kauffman	Pathology	IRRI
7. R. Coffman	Plant Breeding	IRRI, WARDA
8. P. Jennings	Pathology and Breeding	IRRI, CIAT
9. D. MacKenzie	Pathology and Breeding	CIMMYT, IRRI, AVRDC
10. Not named	Weed Science	---

* Other observer/participants will be invited from key institutions including CGIAR, TAC, FAO and others.

Note: None of the proposed participants have been contacted. Please treat this information as confidential.

None of the proposed Phase II participants are, at this time, employed be any of the IARC's and they should therefore serve as independent, non-vested information resources.

TABLE 1: Mandated and implied commodity research activities for the 8 IARC's with crop research responsibilities.

	CROP COMMODITY													
CENTER*	Wheat**	Barley	Rice	Maize	Millet & Sorghum	Potato & Sut Potato	Cassava	Yams	Fava Bean & Lentils	Phaseolus Beans	Pigeon & Chick Peas	Ground-Nuts	Vigna and Soya	Forages
CIAT			I				I			I				I
CIMMYT	I	I		I										
CIP						I								
ICARDA	I	I							I		I			I
ICRISAT					I						I	I		
IITA			I	I		(I)?		I					I	
IRRI			I	(I)										
WARDA			I											

* The Centers listed above conduct crop commodity research. Other centers within the CGIAR-supported center network include IBPGR, IFPRI, ILCA, ILRAD and ISNAR which do not have active research programs for crop commodities, especially in crop protection. (Please note that most Centers have strong collaborative programs in germ plasm collection and preservation with IBPGR.) See Appendix 2 for the complete Center names.

** Includes bread, durum and triticale types.

TABLE 2: Evaluations of the degree of research activity in the components of crop protection in the CGIAR supported IARC network. Commodity groupings reflect direct mandates of Centers and the research activities using the classifications of Anderson (1985) in "International Agricultural Research Centers: Achievements and Potential - Part IV." Evaluations are scored on a scale of 0 to 4, with 0 being no activity and 4 being very high research activity. The assigned scores are solely the responsibility of the author, are based on multiple sources of information and do not imply any judgement on the quality of the research activities.

	CROP COMMODITY													
RESEARCH ACTIVITIES	Wheat	Barley	Rice	Maize	Millet & Sorghum	Potato & Swt Potato	Cassava	Yams	Fava Bean & Lentils	Phaseolus Beans	Pigeon & Chick Peas	Ground Nuts	Vigna and Soya	Forages
INTEGRATION OF PRACTICES	2	2	2	2	2	2	2	2	2	2	2	2	2	
Mechanical Control	0	0	1	0	0	0	0	1	1	1	1	1	2	
Chemical Control	1		2	0	1	1		1	1	1	1	1	2	
Cultural Control	1	1	2	1	2	2	1	1	1	1	1	1	2	
Biological Control	0	0	3	2	0	3	2	1	0	1	0	0	1	
H.P. Resistance	4	3	4	4	4	4	3	3	3	4	3	3	3	2
IPM	0	0	2	1	1	2	0	1	1	2	1	2	1	
Biotechnology	2		3	0	0	2	0	0	0	0	0	0	0	
INFORMATIONAL														
Surveys	2	1	3	2	1	1	0	0	1	1	0	1	1	
Monitoring	3	1	3	1	1	1	0	1	1	1	1	1	1	
Forecasting	0	0	2	1	1	1	0	0	0	1	0	0	1	
Loss Assessment	2	0	3	1	1	1	0	0	0	1	0	2	0	
Economic Thresholds	0	0	2	1	1	2	0	0	0	1	1	2	0	
OTHER TOPICS														
Modelling	0	0	3	2	1	0	0	0	0	0	0	0	1	
Population Dynamics		0	2	2	1	0	0	0	0	0	0	0	0	
Ecology	0	1	2	1	1	1	1	1	1	1	1	2	1	
Basic Pest Science	0	0	3	1	2	1	1	1	1	1	1	2	1	
Sustainability	1		2	2	2	1	0	1	1	1	2	1		

Addendum

Research with pesticides for crop protection strategies extends beyond efficacy studies to include:

- Safer handling of pesticides and technology to safely deliver small amounts of pesticide with little or no exposure to the applicators.

- Pesticide application technology that increases the efficiency of the pesticide applied thereby reducing the amount of pesticide needed.

- Timing of pesticide applications based on biological developments and meteorological events rather than by predetermined schedules.

- Complementary and synergistic effects of pesticides with other crop protection tactics (e.g., W. Fry's work with host plant resistance and fungicide protection for potato late blight disease management).

These and similar topics on pesticide use suggest broad areas of investigation with chemical control practices that should be considered as part of any crop protection research agenda.

APPENDIX C. EXPERT PANEL MEMBERSHIP

Dr. Ronnie Coffman is Professor of Plant Breeding and Head of the Department of Plant Breeding and Biometery at Cornell University. Dr. Coffman was a senior scientist and rice breeder at the International Rice Research Institute for a number of years prior to joining the faculty at Cornell University. He also undertook his dissertation research in the Wheat Program at the International Center for Maize and Wheat Improvement in Mexico. He presently serves on the Board of Trustees for the West African Rice Development Association and continues many international activities as an internationally recognized plant breeder.

Dr. Jerry Doll is Professor of Weed Science at the University of Wisconsin in Madison. Dr. Doll's international experience includes service as a senior scientist at the International Center for Tropical Agriculture in Cali, Colombia. He continues his international activities in his present employment at the University of Wisconsin as a consultant in international agricultural research for weed science.

Dr. Dean Haynes is Professor of Entomology at the Michigan State University. Dr. Haynes recently completed an appointment as Director of Research at the International Center for Insect Physiology and Ecology in Kenya. His present research activities include arid environment insect pest management and the applications of systems science to farming systems.

Dr. Elvis A. Heinrichs is Professor and Head of the Department of Entomology at Louisiana State University. Prior to his present appointment he was Head of the Department of Entomology at the International Rice Research Institute in the Philippines. Dr. Heinrichs is a well-recognized entomologist with considerable research experience on insect pests of rice.

Dr. Harold Kauffman is Director of the International Soybean Resource Base (INTSOY) at the University of Illinois in Urbana. Prior to his present appointment he served as Director of the International Rice Testing Program at the International Rice Research Institute in the Philippines. Preceding that appointment he was a plant pathologist on the All-India Coordinated Rice Improvement Project in Hyderabad. Dr. Kauffman has global experience in field testing crops for biotic and abiotic stresses and agronomic performance.

Dr. David R. MacKenzie is presently Director of the USDA's National Biological Impact Assessment Program in Washington, D.C. Previously he was at the Louisiana State University where he served as Professor of Plant Pathology and Head of the Department of Plant Pathology and Crop Physiology. Prior to that appointment he was Professor of Plant Pathology at the Pennsylvania State University in the Department of Plant Pathology. His experiences include breeding major food crops, plant epidemiology and disease forecasting. As a former member of the Rockefeller Foundation's Special Field Staff he conducted research at the International Center for Maize and Wheat Improvement in Mexico and the International Rice Research Institute in the Philippines and served as Head of the Department of Plant Breeding at the Asian Vegetable Research and Development Center in Taiwan.

Dr. Merle Shepard is Professor and Resident Director of the Clemson Coastal Plains Research and Education Center near Charleston, South Carolina. Dr. Shepard was previously a senior entomologist with the International Rice Research Institute specializing in integrated pest management systems. He is a well recognized expert in organizing discipline-integrated research programs.

Dr. Paul Teng is presently Professor and Head of the Department of Plant Pathology at the University of Hawaii. He recently completed a two-year appointment at the International Rice Research Institute while on leave from the University of Minnesota. At Minnesota he served as a Professor of Plant Pathology specializing in epidemiology, crop loss assessment and disease management systems. He has extensive experience as an advisor to several international organizations in crop protection and has written extensively on the theory and the practice of integrated crop protection.

Dr. Robert Theberge recently completed an assignment at the International Institute for Tropical Agriculture in Nigeria as a plant pathologist in the root crops program and then as project leader for the IITA Outreach Program in Benin. Prior to his appointments at IITA Dr. Theberge was on the scientific

staff of the Rockefeller Foundation stationed in New York City. He is a well recognized plant pathologist and crop protection specialist.

Dr. Arnold Tschanz is presently a senior scientist in the USDA's Animal Plant Health Inspection Service where he heads the pest risk assessment program. Prior to his present appointment he was a plant pathologist at the Asian Vegetable Research and Development Center in Taiwan. He has made significant contributions in research and training in crop protection for several crops and has broad experiences in cropping systems in Asia.

In addition to the Expert Panel members, an observer, Dr. Charles Delp, was invited to participate in the three-day conference.

Dr. Charles Delp is a plant pathologist recently retired from the DuPont Chemical Company where he headed a research program developing pesticides for agricultural crops. Dr. Delp has extensive commercial experience with pesticides and is considered a world authority on the contemporary problems in using pesticides in agricultural production. He has written extensively on the use of pesticides in the tropics. His work includes the theoretical and practical aspects of pesticide use, resistance to pesticides and methods to effectively include chemical control practices into Integrated Pest Management systems. Dr. Delp presently serves as Executive Director of the American Phytopathology Society's Office of International Programs which supports global efforts in research and teaching in crop protection.

APPENDIX D. REVIEW PANEL (MAIL-OUT)

LIST OF MAIL-OUT REVIEWERS

Dr. Robert Herdt

Dr. W. Clive James

Dr. Peter Jennings

Dr. Hei Leung

Dr. H. D. Thurston

Dr. Neik Van der Graaff

Dr. Rob Williams

APPENDIX E

CROP PROTECTION RESEARCH
AGENDA
JULY 11-13, 1989

Tuesday	
8:30 - 10:00	Introductions, Terms of Reference, Agenda, Final Report
10:00 - 10:30	Break
10:30 - Noon	IARC Contributions to Crop Protection
Noon - 1:00	Lunch (all meals are "on your own")
1:00 - 3:00	Assessment of Current IARC Activities
3:00 - 4:00	Current and Future Problems* for Crop Protection Research
4:00 - 7:30	Special session - Rice Biosafety Dinner (on your own)
Wednesday	
8:30 - Noon (with coffee break)	Constraints that limit crop protection-research efforts (e.g., financial, policy, services, logistics, scientific, technical, partnerships, disciplinary issues, geography, site specificity, public relations (e.g., chemicals) etc.)
Noon - 1:00	Lunch (on your own)
1:00 - 5:00	Options that should be considered for Centers: o Programmatic restructuring o Contract research o Regional research centers o Designated lead centers o Project (or P.I.) funding o Institutional Collaborations (Networking) o Other Proposals

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* This topic should be broadly viewed to include all components of Crop Protection plus biosafety, photo sanitation, seed health, quarantines eradication, IPM, HPR, Chemicals, Cultural Control, Biological Control, etc.

For CG System:

- o Designated allocations in budgets for Crop Protection
- o Competitive Grants for Crop Protection Research
  - Peer Review?
  - Targeted?
  - Restricted?
  - Management?
- o Center for Crop Protection
- o Technical Secretariat/Advisory Board
- o "Center without Walls"
- o Other

Thursday

8:30 - Noon	Organization of Alternatives (P. Teng)
Noon - 1:00	Lunch (on your own)
1:00 - 3:00	Summary and Discussion
3:00 -	Adjourn

APPENDIX F. DEFINITIONS

Biological control: Techniques which use a living organism or its product to restrict the development of a pest.

Biotechnology: broadly defined, includes any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants or animals, or to develop microorganisms for specific uses--including recently developed techniques such as genetic engineering and cell fusion.

Chemical control: Practice whereby chemical compounds are used to slow the development of a pest.

Cultivar: Genetically improved variety.

Cultural control: Localized practice(s) whereby a crop is manipulated (e.g., crop rotation, mixed-cropping, row spacing, etc.), to lessen the impact of pest(s).

Crop loss: Reduced production for a specific crop on a regional level.

Crop protection: One or more combinations of strategies such as biological, chemical, cultural and mechanical control practices used to lessen the impact of a pest.

Disease: Disturbance in the normal development of a plant caused by a pathogen which may result in yield loss.

Durable resistance: Host plant resistance which remains effective for long periods of time.

Economic threshold: The level at which control measures are determined to prevent an increase in pest populations from reaching the economic injury level (i.e., monetary inputs are less than monetary losses).

Forecasting: Mathematical equation used to predict the likelihood of pest(s) occurrence and/or their impact on a crop.

Fungicide: Specific chemical agent used to control a fungal pathogen.

Herbicide: Specific chemical agent used to control a weed pest.

Host plant resistance: Genetic ability of a cultivar to overcome completely, or to some degree, the effect of a pest.

Insecticide: Specific chemical agent used to control an insect pest.

IPM: (Integrated Pest Management) Philosophy of managing pests which draws upon the inherent controls of nature, the predators, pathogens, parasites, competitors, antagonists, natural plant resistance and tolerance to attack; and components of the physical environment which can be altered in the field to the detriment of the pests or the benefit of the natural enemies of the pests.

Loss assessment: Regional or local determination in the amount of loss for a crop which may be assessed through inquiries, field experiments, surveys and/or remote sensing.

Mechanical control: Practice whereby mechanical implements are used to manipulate the development of a pest (e.g., plowing crop residues).

Modeling: A generalized hypothetical mathematical equation used to predict the impact, development of pest(s), their interactions and impact on a crop.

Pathogen: Pest organisms such as bacteria, fungi, nematodes, viruses, etc., which can incite disease.

Pest: General term used to refer to weeds, plant pathogens, insects, mites, nematodes, birds, rodents, etc., as unwanted organisms.

Pesticide: Chemical agent used to control a plant pest.

Survey: Localized or regional visual determination of the presence or absence of a pest.

Sustainable agriculture: Combinations of production practices that result in long-term productivity of a cropping system.

Yield loss: Reduction in yield for a specific crop in a localized, harvested area.

APPENDIX G. RESOURCE DOCUMENTS

AVRDC - AVRDC: A Strategy for Progress, Program and Funding Requirements for The Asian Vegetable Research and Development Center for the Period 1981-1985. October 1979.

CGIAR - CGIAR 1987/88 Annual Report. September 1988. 82 pp.

CIAT - CIAT in the 1980s Revisited. A Medium-Term Plan for 1986 to 1990. 1985.

CIAT - CIAT Report 1988. May 1988. 130 pp.

CIAT - Program Plans and Funding Requirements 1989 - 1993. 1988. 84 pp.

CIMMYT - CIMMYT in the Year 2000. Draft Strategic Plan. June 15, 1988.

CIMMYT - CIMMYT's Five-Year Budget Proposal 1990 - 1994. 1989. 88 pp.

CIP - CIP Profile 1972-2010. July 1987.

CIP - CIP Program Plans and Needs 1988 - 1992. 1988. 80 pp.

CIP - International Potato Center Annual Report 1988. 1988. 210 pp.

IBPGR - Annual Report IBPGR 1987. 1988. 86 pp.

ICARDA - Food Legume Improvement Program Annual Report for 1987.

ICARDA - Pasture, Forage and Livestock Program Annual Report to 1987.

ICARDA - Cereal Improvement Program Annual Report for 1987.

ICARDA - Genetic Resources Program Annual Report for 1987.

ICARDA - ICARDA Annual Report 1987. 1988. 76 pp.

ICARDA - Farm Resource Management Program Annual Report for 1988.

ICARDA - Seed Production Project Annual Report for 1988.

ICARDA - Guiding ICARDA Into the 21st Century: A Strategic Plan. Third Draft. March 1988.

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APPENDIX H. IARC RESOURCE ALLOCATIONS

Information was compiled from the following IARC documents:

CIAT	-	from tables 1, 2, 3 and 5 of the CIAT Program plans and Funding requirements 1989-1994.
CIMMYT	-	from tables 6.3 and 6.10 of CIMMTY's Five-Year Budget Proposal 1990-1994.
CIP	-	from tables 11.1, 11.2 and 11.3 of CIP's Program Plans and Needs - 1988-1992.
ICARDA	-	from table 1.4 and Annex 14 of the ICARDA Medium-Term plan 1990-1994, consolidation and change.
ICRISAT	-	from tables 1 and 3 of the ICRISAT Medium-Term Program Plans and Funding Requirements 1989-1993.
IRRI	-	from table 20 of Complementing the Strategy Work Plan for 1990-1994, IRRI Toward 2000 and Beyond.
WARDA	-	from tables 17 and 22 of WARDA's Medium-Term Implementation Plan: 1990-1994.

Note: Column totals do not match the actual Center totals as given in the tables. Values differ as a result of different reporting procedures by the Centers and the assumptions used to estimate dollar values from proportions.

CIAT (Allocations in U.S. $,000)	1989	1993
I. RESOURCE CONSERVATION & MANAGEMENT		
1. Water Management Res.	1,304	1,824
2. Soils Mgmt & Conservation		
3. Agro Climatology		
29. Agro Forestry		
4. Germ Plasm		
a. Research on Cons & Div	Included with Sec. 4b.	
b. Collection	1,839	1,992
c. Cons., Char. & Doc.	Included with Sec. 4b.	
II. CROP PRODUCTION RESEARCH		
4. Germ Plasm		
d. Enhancement	Included with Sec. 4e.	
e. Breeding/Improvement	5,016	5,518
f. International Trials	Included with Sec. 4e.	
5. Seed Production	Included with Sec. 10 & 11	
6. Crop Systems Research	Included with Sec. 10 & 11	
10. Plant Nutrition	Included with Sec. 9	
11. Machinery Res. & Dev.	2,441	2,904
9. Plant Protection	2,040	2,489
8. Crop-Livestock Systems	Included with Sec. 12	
III. LIVESTOCK PRODUCTION		
7. Livestock Systems	Included with Sec. 12	
12. Livestock Nutrition	1,070	1,618
13. Livestock Reproduction	-	-
14. Livestock Diseases	-	-
IV. COMMODITY CONVERSION & UTILIZ.		
28. Comm. Conv. & Util.	-	-
V. ANAL. HUMAN NUTRITION LINKAGES		
25. Nutrition Analysis	100	249
VI. FOOD & AGR POLICY RESEARCH		
22. Econ. & Social Analysis (Micro)		
23. Market Analysis	Included with #25	
24. Policy Analysis		
VII. EXPLORATORY, IMPACT & METHOD		
18. Res. on Approaches	1,406	2,448
26. Research on Research	-	-
27. Exploratory Research	-	-
VIII. INST. BUILD., TRAIN. & NETWORK		
15. Training	3,980	4,979
16. Conferences & Seminars	1,037	1,369
17. Documentation & Dissem.	1,772	2,157
19. Counselling & Advising NARS	1,772	1,867
20. Technical Assistance	669	871
21. Coordination of Networks	1,572	2,033
Management & Administration	6,354	7,468
TOTALS	**33,443**	**41,489**

CIMMYT (Allocations in U.S. $,000)	1989	1989
I. RESOURCE CONSERVATION & MANAGEMENT		
1. Water Management Res.	-	-
2. Soils Mgmt & Conservation	-	-
3. Agro Climatology	-	-
29. Agro Forestry	-	-
4. Germ Plasm		
a. Research on Cons & Div	-	-
b. Collection	1,478	3,026
c. Cons., Char. & Doc. Included with #4b		
II. CROP PRODUCTION RESEARCH		
4. Germ Plasm		
d. Enhancement Included with #4b		
e. Breeding/Improvement Included in Sec. 4f		
f. International Trials	8,380	9,276
5. Seed Production	-	-
6. Crop Systems Research	2,587	3,749
10. Plant Nutrition	-	-
11. Machinery Res. & Dev.	-	-
9. Plant Protection	2,120	3,106
8. Crop-Livestock Systems	-	-
III. LIVESTOCK PRODUCTION		
7. Livestock Systems	-	-
12. Livestock Nutrition	-	-
13. Livestock Reproduction	-	-
14. Livestock Diseases	-	-
IV. COMMODITY CONVERSION & UTILIZ.		
28. Comm. Conv. & Util.	-	-
V. ANAL. HUMAN NUTRITION LINKAGES		
25. Nutrition Analysis	483	897
VI. FOOD & AGR POLICY RESEARCH		
22. Econ. & Social Analysis (Micro) Included in Sec. 25		
23. Market Analysis Included in Sec. 25		
24. Policy Analysis Included in Sec. 25		
VII. EXPLORATORY, IMPACT & METHOD		
18. Res. on Approaches	-	-
26. Research on Research	-	-
27. Exploratory Research	-	-
VIII. INST. BUILD., TRAIN. & NETWORK		
15. Training	5,359	4,927
16. Conferences & Seminars Included in Sec. 20		
17. Documentation & Dissem.	1,346	1,454
19. Counselling & Advising NARS Included with #20		
20. Technical Assistance	1,091	643
21. Coordination of Networks		
Management & Administration	6,517	6,564
Capital (Addition & Replacements)	4,043	2,155
Working Capital	0	7,630
Interest & Other Income	893	250
TOTALS	**32,521**	**43,485**

CIP (Allocations in U.S. $,000)	1989	1993
I. RESOURCE CONSERVATION & MANAGEMENT		
1. Water Management Res.	-	-
2. Soils Mgmt & Conservation	-	-
3. Agro Climatology	-	-
29. Agro Forestry	-	-
4. Germ Plasm		
a. Research on Cons & Div	853	858
b. Collection	89	89
c. Cons., Char. & Doc.	288	288
II. CROP PRODUCTION RESEARCH		
4. Germ Plasm		
d. Enhancement	200	200
e. Breeding/Improvement	1,167	1,170
f. International Trials	-	-
5. Seed Production	-	-
6. Crop Systems Research	540	540
10. Plant Nutrition	41	41
11. Machinery Res. & Dev.	-	-
9. Plant Protection	1,647	1,647
8. Crop-Livestock Systems	-	-
III. LIVESTOCK PRODUCTION		
7. Livestock Systems	-	-
12. Livestock Nutrition	-	-
13. Livestock Reproduction	-	-
14. Livestock Diseases	-	-
IV. COMMODITY CONVERSION & UTILIZ.		
28. Comm. Conv. & Util.	-	-
V. ANAL. HUMAN NUTRITION LINKAGES		
25. Nutrition Analysis	41	41
VI. FOOD & AGR POLICY RESEARCH		
22. Econ. & Social Analysis (Micro)	214	233
23. Market Analysis	81	81
24. Policy Analysis	198	198
VII. EXPLORATORY, IMPACT & METHOD		
18. Res. on Approaches	-	-
26. Research on Research	-	-
27. Exploratory Research	-	-
VIII. INST. BUILD., TRAIN. & NETWORK		
15. Training	2,153	2,153
16. Conferences & Seminars	-	-
17. Documentation & Dissem.	-	-
19. Counselling & Advising NARS	2,628	2,635
20. Technical Assistance	1,812	1,812
21. Coordination of Networks	2,376	2,860
Management & Administration	4,763	2,333
Price Requirement	1,473	3,992
Capital	890	550
Working Capital	125	94
Misc. (house for D.G.)	250	-
TOTALS	**21,788**	**22,779**

ICARDA (Allocations in U.S. $,000)	1989	1993
I. RESOURCE CONSERVATION & MANAGEMENT		
1. Water Management Res.	467	394
2. Soils Mgmt & Conservation	406	961
3. Agro Climatology	1,721	2,140
29. Agro Forestry	-	-
4. Germ Plasm		
a. Research on Cons & Div	467	870
b. Collection	467	462
c. Cons., Char. & Doc.	1,435	1,813
II. CROP PRODUCTION RESEARCH		
4. Germ Plasm		
d. Enhancement	549	1,179
e. Breeding/Improvement	5,461	2,747
f. International Trials	735	1,179
5. Seed Production	280	349
6. Crop Systems Research	686	1,002
10. Plant Nutrition	999	1,192
11. Machinery Res. & Dev.	30	45
9. Plant Protection	1,839	2,965
8. Crop-Livestock Systems	810	2,312
III. LIVESTOCK PRODUCTION		
7. Livestock Systems	436	653
12. Livestock Nutrition	137	567
13. Livestock Reproduction	30	190
14. Livestock Diseases	30	304
IV. COMMODITY CONVERSION & UTILIZ.		
28. Comm. Conv. & Util.	123	263
V. ANAL. HUMAN NUTRITION LINKAGES		
25. Nutrition Analysis		86
VI. FOOD & AGR POLICY RESEARCH		
22. Econ. & Social Analysis (Micro)	362	961
23. Market Analysis	30	131
24. Policy Analysis	123	131
VII. EXPLORATORY, IMPACT & METHOD		
18. Res. on Approaches	1,249	2,439
26. Research on Research	30	304
27. Exploratory Research	280	453
VIII. INST. BUILD., TRAIN. & NETWORK		
15. Training	4,948	8,967
16. Conferences & Seminars	936	1,700
17. Documentation & Dissem.	2,495	3,749
19. Counselling & Advising NARS	1,902	2,530
20. Technical Assistance	936	1,700
21. Coordination of Networks	779	1,963
Management & Administration	3,994	4,695
Operations	2,691	3,607
Price Provision	0	9,165
Equipment	2,000	2,000
Buildings	0	1,000
TOTALS	**27,444**	**45,336**

ICRISAT (Allocations in U.S. $,000)	1989	1993
I. RESOURCE CONSERVATION & MANAGEMENT		
1. Water Management Res.		
Included in Sec. 2		
2. Soils Mgmt & Conservation	1,809	2,076
3. Agro Climatology		
Included in Sec. 2		
29. Agro Forestry	-	-
4. Germ Plasm		
a. Research on Cons & Div		
Included in Sec. 4b		
b. Collection	245	239
c. Cons., Char. & Doc.		
Included in Sec. 4b		
II. CROP PRODUCTION RESEARCH		
4. Germ Plasm		
d. Enhancement		
Included in Sec. 4e		
e. Breeding/Improvement	5,580	5,234
f. International Trials		
Included in Sec. 4e		
5. Seed Production		
Inc. with Sec. 11		
6. Crop Systems Research		
Inc. with Sec. 11		
10. Plant Nutrition		
Included in Sec. 11		
11. Machinery Res. & Dev.	5,396	5,327
9. Plant Protection	3,992	4,428
8. Crop-Livestock Systems	-	-
III. LIVESTOCK PRODUCTION		
7. Livestock Systems	-	-
12. Livestock Nutrition	-	-
13. Livestock Reproduction	-	-
14. Livestock Diseases	-	-
IV. COMMODITY CONVERSION & UTILIZ.		
28. Comm. Conv. & Util.	495	485
V. ANAL. HUMAN NUTRITION LINKAGES		
25. Nutrition Analysis		
Inc. in Sec. 24		
VI. FOOD & AGR POLICY RESEARCH		
22. Econ. & Social Analysis (Micro)		
Inc. in Sec. 24		
23. Market Analysis		
Inc. in Sec. 24		
24. Policy Analysis	543	608
VII. EXPLORATORY, IMPACT & METHOD		
18. Res. on Approaches		
Included in Sec. 27		
26. Research on Research	226	202
27. Exploratory Research	136	253
VIII. INST. BUILD., TRAIN. & NETWORK		
15. Training	2,418	2,471
16. Conferences & Seminars	415	614
17. Documentation & Dissem.	955	940
19. Counselling & Advising NARS		
Included in Sec. 20		
20. Technical Assistance	269	272
21. Coordination of Networks	1,131	1,135
Management & Administration	8,582	8,947
TOTALS	**32,122**	**33,231**

IRRI (Allocations in U.S. $,000)	1989	1993
I. RESOURCE CONSERVATION & MANAGEMENT		
1. Water Management Res.	706	706
2. Soils Mgmt & Conservation	1,415	1,415
3. Agro Climatology	646	620
29. Agro Forestry		
4. Germ Plasm		
a. Research on Cons & Div	173	165
b. Collection	79	86
c. Cons., Char. & Doc.	736	726
II. CROP PRODUCTION RESEARCH		
4. Germ Plasm		
d. Enhancement	2,843	2,967
e. Breeding/Improvement	1,582	1,680
f. International Trials	894	897
5. Seed Production	274	328
6. Crop Systems Research	2,001	1,940
10. Plant Nutrition	1,121	1,177
11. Machinery Res. & Dev.	240	253
9. Plant Protection	1,986	2,004
8. Crop-Livestock Systems	32	33
III. LIVESTOCK PRODUCTION		
7. Livestock Systems	-	-
12. Livestock Nutrition	-	-
13. Livestock Reproduction	-	-
14. Livestock Diseases	-	-
IV. COMMODITY CONVERSION & UTILIZ.		
28. Comm. Conv. & Util.	112	111
V. ANAL. HUMAN NUTRITION LINKAGES		
25. Nutrition Analysis	-	-
VI. FOOD & AGR POLICY RESEARCH		
22. Econ. & Social Analysis (Micro)	1,069	1,009
23. Market Analysis	248	232
24. Policy Analysis	57	56
VII. EXPLORATORY, IMPACT & METHOD		
18. Res. on Approaches	539	514
26. Research on Research	-	-
27. Exploratory Research	-	-
VIII. INST. BUILD., TRAIN. & NETWORK		
15. Training	4,118	4,122
16. Conferences & Seminars	628	628
17. Documentation & Dissem.	983	983
19. Counselling & Advising NARS	118	118
20. Technical Assistance	86	86
21. Coordination of Networks	512	512
29. Soil Microbiology	767	791
30. Plant Physiology	984	1,145
General Administration	3,994	3,764
General Operations	1,945	1,945
TOTALS	**30,838**	**31,013**

WARDA (Allocations in U.S. $,000)	1990 - 1994
I. RESOURCE CONSERVATION & MANAGEMENT	
1. Water Management Res.	457
2. Soils Mgmt & Conservation	621
3. Agro Climatology	-
29. Agro Forestry	-
4. Germ Plasm	
a. Research on Cons & Div	65
b. Collection	65
c. Cons., Char. & Doc.	65
II. CROP PRODUCTION RESEARCH	
4. Germ Plasm	
d. Enhancement	545
e. Breeding/Improvement	1,047
f. International Trials	546
5. Seed Production	231
6. Crop Systems Research	688
10. Plant Nutrition	427
11. Machinery Res. & Dev.	
9. Plant Protection	599
8. Crop-Livestock Systems	-
III. LIVESTOCK PRODUCTION	
7. Livestock Systems	-
12. Livestock Nutrition	-
13. Livestock Reproduction	-
14. Livestock Diseases	-
IV. COMMODITY CONVERSION & UTILIZ.	
28. Comm. Conv. & Util.	262
V. ANAL. HUMAN NUTRITION LINKAGES	
25. Nutrition Analysis	65
VI. FOOD & AGR POLICY RESEARCH	
22. Econ. & Social Analysis (Micro)	328
23. Market Analysis	-
24. Policy Analysis	-
VII. EXPLORATORY, IMPACT & METHOD	
18. Res. on Approaches	731
26. Research on Research	-
27. Exploratory Research	-
VIII. INST. BUILD., TRAIN. & NETWORK	
15. Training	345
16. Conferences & Seminars	246
17. Documentation & Dissem.	574
19. Counselling & Advising NARS	164
20. Technical Assistance	736
21. Coordination of Networks	261
Capital Investment	3,410
Price Increase	2,490
TOTALS	**14,968**

APPENDIX I. U.S. ALLOCATIONS FOR CROP PROTECTION RESEARCH

Plant science research expenditures in U.S. dollars ($) and scientists years (sy) for all sources of public sector plant science research (excluding forestry) and the associated data for crop protection research.

Plant Science Expenditures

Source	Funds ($)
Federal	
CSRS	98,466,931
CGCA	11,900,611
Other	38,882,508
Non-Federal	395,856,078
TOTAL	$544,706,128

Plant Science Scientist years (SY)

Source	SY
Formula	2126.6
Grants	160.2
State	690.4
TOTAL	2977.3

Crop Protection Control of:	Funds	SY
Horticultural Crops		
Insects, Mites, Slugs and Snails	25,487,583	140.0
Diseases and Nematodes	40,645,022	237.8
Weeds and Other Hazards	6,854,407	36.7
Agronomic Crops		
Insects, Mites, Snails and Slugs	33,620,058	201.8
Diseases and Nematodes	38,268,860	224.0
Weeds and Other Hazards	20,338,601	103.7
TOTAL	$165,205,531	944**

* Cost per SY for plant scientists = $182,953
** Cost per SY for crop protection scientists = $175,006

Source: Current Research Information System, Cooperative State Research Service, U.S. Department of Agriculture, National Agricultural Library, Beltsville, Maryland, U.S.A.

APPENDIX J. TRENDS OF PESTICIDE USE IN THE TROPICS

ADAPTED FROM AN ARTICLE BY C. J. DELP

by

Robert Theberge

Pesticides are chemical agents used to control plant pests (insects, pathogens, weeds) and have become an indispensable part of modern crop agriculture. Current trends in the tropics indicate a significant increase in the use of pesticides. This increased use of pesticides is particularly prominent on rice crops and on plantation export crops.

Some of the factors that are impacting the use of pesticides in the tropic include the questionable effectiveness of government regulations, concerns for the misuse of pesticides and the pirating of commercial pesticides.

Many tropical countries have neither effective regulation of pesticide use nor the means to enforce compliance with regulations.

Many experts familiar with the problems of pesticide use in the tropics have stressed the need to develop Integrated Pest Management practices appropriate to non-traditional agriculture, especially with emphasis on biologic control agents. This may in some cases require the recommendation to use pesticides when appropriate. This can then contribute to concerns for safety and the prospects of misuse.

As the potential market of pesticide sales increases in the tropics, and as technologies are developed to safely handle these materials, research and development on the use of pesticides on tropical crops will be of increasing importance in agricultural development.

Interest in pesticides in the tropics continues to be counterbalanced with the high cost of pesticide research and development which now can reach $30-40 million for each product. This enormous cost, coupled with the lack of adequate patent and trademark protection in some tropical countries, makes pesticide development a sometimes poor business venture in anything but the largest markets.

Unfortunately, trends towards increased pesticide use in the tropics has been followed with an increased occurrence of pest resistance to certain pesticides. This "breakdown in pesticide effectiveness" limits market potential for an individual pesticide and requires the development of new products on an almost a continuing basis.

Coupled with the issues of pesticide use is the broadly felt need for more sustainable technologies for crop production systems. Unfortunately for the small land holder, many of the existing IPM programs that could contribute to sustainable production are either too complicated or lack the necessary supporting infrastructure for their acceptance. Moreover, the lack of effective pesticide safety training in many tropical production systems continues to be a real-world limitation.

The Food and Agricultural Organization's (FAO) code of good practices with pesticides in the Third World is recognized as a very significant contribution towards a reasonable pesticide policy. FAO's efforts, along with industry, government and environmental groups are providing needed programs and regulations for pesticide use. These efforts must be matched with an enormous training commitment so that pesticides can be used not only effectively, but safely in tropical agriculture.

Many critics of the use of pesticides in the tropics point to the apparent failure to get information to grower, especially small scale producers. A recent study conducted by the U.S. Congress Office Technology Assessment speaks to this point. In many African agricultural systems the roles played by women in agricultural production have been largely neglected. Women in Africa contribute up to 80% of all farm labor. There is apprehension that pesticide training programs have failed to address this gender distinction.

The enormous need for appropriate pesticide training in tropical agricultural production calls for more research, development, technology transfer and training, especially at the grower level. These items are considered to represent critical problems that are compounded with the extensive use of a few

cultivars in monocropping systems. This situation contributes to an increased vulnerability to pest problems and consequently to an overdependence on pesticides for production agriculture.

The appropriate role of pesticides in tropical agricultural production is in need of attention. Left unattended, private sector development will pursue only those markets with significant market potential. The apparent weakness of public sector programs in the Third World to support the use of pesticides with activities such as training, regulation and safety further aggravate the situation. These concerns, coupled with the potential for genetic vulnerability with host plant resistance, have led to the current situation that is presently in need of attention. The appropriate roles of the IARCs in addressing these issues needs to be clarified.

Reference

Delp, C. J. 1986 "Trends with Tropical Pesticide Use" In: Proceedings of the Second International Conference on Plant Protection in the Tropics, Malaysian Plant Protection Society, pages 25-37.

APPENDIX K. CRITERIA FOR CROP PROTECTION RESEARCH ACTIVITIES

The usual justification for research expenditures in crop protection give consideration to the direct and indirect costs of pests and pathogens on production agriculture. Some aspects of this approach are flawed.

First, the basic biology necessary to understand the impacts of pests and pathogens is a patchwork of knowledge that in many instances is inadequate or does not match the identified problem. This then requires imaginative programming choices or just sheer luck to balance existing knowledge against plant pest and disease caused losses.

Second, for the IARCs information on pest and pathogen caused crop losses on a global scale is grossly inadequate for setting research priorities. A recent draft chapter by James, Teng and Nutter point out the impressive advances that have been made in the past few decades (see References) but there is still a lack of solid information for strategically planning crop protection research globally.

In addition to the crop loss justifications for crop protection research another concern that is often voiced is production agriculture's overdependence on pesticides and how crop protection research might relieve that overdependence. These concerns for pesticide use may well be legitimate, but the trade-offs are often complicated by laws, economics and grower perceptions of risk. These are further complicated with other externalities that drive the dependency on pesticides. This situation makes for difficult choices for research program prioritization.

The International Agricultural Research Centers have not needed to address these questions directly in their past program planning for one simple reason; their emphasis on host plant resistance. As they focused on host plant resistance, programmatic decisions were relatively simple and straightforward.

The situation is now changing for crop protection research programs, especially for the IARCs. As evidence accumulates on the extent of global crop losses and as economic values for these losses are calculated more precisely, questions are being asked of researchers as to how they might prevent these pest caused annual losses. James, et al., have calculated that the global losses to disease alone totals each year U.S. $ 90 billion! And, of the 900,000,000 metric tons lost each year to diseases, 250,000,000 metric tons are cereals. This represents about 50% more than the projected grain deficit for developing countries in the year 2000.

It is clearly evident that host plant resistance will continue to play a major role in crop protection programs at the IARCs. But that tactic will need to be complimented with other tactics, integrated into a crop protection package.

The following criteria were developed by the FAO/UNEP Expert Panel on Integrated Pest Control in Agriculture. These criteria are considered important when evaluating on which basis to invest limited resources to obtain maximum benefit in crop protection.

CRITERIA FOR SELECTION OF IPM PROJECT IMPLEMENTATION

Preamble:

It is recognized that IPM project implementation could be considered in one of two contrasting situations.

Situation 1 faces acute problems of misuse and abuse of pesticides. Here the aim is to alleviate the pesticide use problems.

Situation 2 faces pest problems either where pesticide use is not yet excessive or where there is over-reliance on chemical control. The aim here is to prevent the existing conditions from deteriorating to a point where pesticide dependence increases the vulnerability of the crop. Within Situation 2 there are two contrasting situations: one is where the problem is a newly introduced pest of exotic origin. The other is where IPM can be introduced easily by copying an existing example or because farmers are not yet conditioned to pesticide use.

The selection of crops and regions for implementing IPM must be made objectively and based on criteria as outlined below:

1. First priority should be given to situations which are already experiencing serious problems of pesticide abuse, symptoms of which are:
   - pesticide resistance
   - pest resurgence
   - secondary pest outbreaks as a result of disturbances in natural balances
   - boom-and-bust cycles in crop or environment
   - risk of acute or chronic poisoning
2. The crop satisfying Criterion 1 must be cultivated extensively, be of crucial importance to the livelihood of the farmers, and be of adequate national importance.

3. The pest(s) on the crop(s) under consideration must have a high potential of success with IPM.

4. Adequate local research support must be available to help in the step-by-step improvement of the IPM technology as the project progresses.

5. Adequate infrastructure support through extension must be present to ensure effective implementation of the project.

6. Local expertise must be available to insure continuity of the project activities after the support has ended.

7. The region selected for project implementation must be one where the crop has sufficient scope and economic importance to repay the investment in IPM.

APPENDIX L. ACRONYMS

AVRDC	Asian Vegetable Research and Development Center
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIBC	Commonwealth Institute for Biological Control
CICP	Center for Integrated Crop Protection
CIMMYT	Centro Internacional de Majoramiento de Maiz y Trigo
CIP	Centro Internacional de la Papa
FAO	Food and Agricultural Organization of the United Nations
HPR	Host Plant Resistance
IARC	International Agricultural Research Center
IBPGR	International Board for Plant Genetic Resources
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIPE	International Center for Insect Physiology and Ecology
ICRAF	International Center for Research in Agro-Forestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Center for Africa
ILRAD	International Laboratory for Research on Animal Diseases
INIBAP	International Network for the Improvement of Banana and Plantain
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
ISNAR	International Service for National Agriculture Research
NARS	National Agricultural Research System
TAC	Technical Advisory Committee of the CGIAR
USAID	United States Agency for International Development
WARDA	West African Rice Development Association

CGIAR LIBRARY

EVALUATION OF CROP PROTECTION

RESEARCH, TRAINING AND TECHNOLOGY TRANSFER

at the

INTERNATIONAL AGRICULTURAL RESEARCH CENTERS

With Recommendations

EXPANDED SUMMARY REPORT

September 1989

INTRODUCTION

A panel of 10 crop protection specialists, each with experience at one or more International Agricultural Research Center (IARC) met in Washington, D.C. on July 11-13, 1989. The panel was asked to consider various dimensions of existing programs in crop protection at individual Centers including current research activities and issues, problems and constraints to crop production research, training and technology transfer with their partners and clients. The perceived need is to strengthen the gains already made in host plant resistance through additional research in crop protection in ways that will allow integration of the developed technology into crop production systems. From these discussions came a number of options that would be expected to contribute to strengthening international crop protection efforts at the IARCs. These points formed the basis for developing some specific recommendations.

NEEDS

Some of the needs identified by the panel were:

- More senior scientific staff qualified to conduct crop protection research, particularly in weed science and nematology.
- Expansion of training activities in crop protection.
- More networking of research partnerships.
- Stronger alternatives for research organizations, especially to compensate for the site specificity needs of crop protection research.
- Development of new methodologies, especially for prediction.
- More access to modern communications technology.
- More direct support for crop protection research activities.
- Better approaches to the problems of site specificity in crop protection research.

An analysis of the current expenditures by IARCs shows them to be significantly underinvested in crop protection research. Most Centers typically allocate 6 to 8% of their budgets to crop protection research. Comparative values for public sector efforts in the United States shows crop protection research to be greater than 30% of the annual investment in the plant sciences.

The panel recognized that adjustments to correct this apparent underinvestment by the IARCs in crop protection research must be done in ways to support and supplement the existing and successful host plant resistance breeding programs while encompassing other tactics, methods and approaches.

PROPOSED CHANGES

The panel identified a number of proposed changes in both policies and programs that would enhance crop protection research at the IARCs and strengthen their partnership activities. They are offered here for consideration.

Policy Changes:

Some of the policy changes suggested by the panel included:

- o A clear statement should be made by the IARCs or the Consultative Group on International Agricultural Research (CGIAR) on the appropriate use of all of the components of integrated crop protection, including pesticides.

- o "Off the top" budget should be used to support interdisciplinary research including intracenter, intercenter and interagency efforts.

- o Criteria are needed for judging the success of research, training and technology transfer programs in crop protection.

- o Special project funding for crop protection research should be given consideration as a way of targeting research activities of specific need.

- o Contract research [sensu the International Potato Center (CIP)] with both public and private sector institutions should be considered as one way of getting specific crop protection research answers or specialized research services.

- o Each Center should assign a portion of one senior scientist's time to global issues in crop protection to encourage a broader perspective at each of the Centers.

- o Each Center should revise its mission statement to include a perspective on crop protection.

- o Each Center should consider establishing policy to foster a more holistic approach to crop protection problem solving through research, training and technology transfer.

- o The IARCs should given greater emphasis to crop protection training and crop protection technology transfer.

- o Centers should establish career paths for senior and professional staff with special emphasis given to attract scientific excellence.

Program Changes:

Some of the program changes suggested by the panel included ways to strengthen crop protection research at the Centers.

- o A system-wide crop protection program could be created to serve as a network for improved communication, coordination and collaboration with a designated champion to coordinate the various activities. The network would hold an annual conference on crop protection that might include an expanded attendance beyond the Center's to include partners, private industry, and perhaps others.

- o The proposed network would provide a mechanism for interinstitutional cooperation. It could also serve as a mechanism for the exchange of scientists and/or the rotation of crop protection specialists among Centers and partner institutions. Such a network could prove

to be very effective for identifying desirable linkages between institutions and coupling those efforts with corresponding activities on a global scale. It was noted that CIP already has a comparable network in place that is judged to be functioning quite effectively. The CIP model is worthy of more thorough study for its application to crop protection research.

- The panel members considered contract research a desirable way of acquiring specifically needed knowledge in areas of crop protection. Again, CIP is using contract research very effectively and this approach seems appropriate for applications in crop protection research.

- Some aspects of crop protection research support, such as bibliographic services, taxonomic identification and assistance in international shipments of biological materials, might best be provided through service contracts. Recognized authorities in these services such as CABI's Commonwealth Institute for Biological Control, the Consortium for Integrated Crop Protection and similar existing institutions could provide much needed assistance to IARC crop protection scientists, but they would need financial support for such services.

- A standardized mechanism should be created to provide external review teams for specific crop protection research projects. A more thorough and focused peer review for IARC crop protection scientists would be of significant benefit.

- IARC peer review panels for crop protection research should include some national program scientists. Representatives from national programs could also help the IARC scientists identify crop protection problems and hence they should be included in the research planning process.

- Consideration should be given to stationing some Center senior staff in national programs for defined periods of time and for special projects in crop protection.

- A mechanism should be developed to clearly define the objectives and limits to the number of crop protection projects to be undertaken, given the present limitation on human capital resources in the CGIAR system. Some of the current projects studied by the panel are stretched too thin for effective impacts.

- An effective method is needed to monitor, evaluate and document the impact of crop pests on global food security. This information would assist in the allocation of resources and the direction of research programs toward priority problems. Given the present limited numbers of senior scientists assigned to crop protection research, an effective mechanism for deciding which problems will be selected for attention has become particularly critical.

OPTIONS

After evaluating and discussing the issues, problems, constraints and needs of the IARCs for crop protection research, the panel developed the following three options for consideration:

- o An IARC Network for Crop Protection
- o A Crop Protection Center-Without-Walls
- o A Center for Crop Protection Research

A Network:

As proposed here, an IARC network with a leader and perhaps a small support staff would provide communication to the "key players" in the IARCs, to their partners and to their clients. The network would have the broad mission of facilitating crop protection research, training and technology transfer for appropriate clients. The network would do this by providing assistance and perhaps access to limited resources, as appropriate. An IARC Crop Protection Network would serve many of the IARCs needs for organization and coordination of crop protection research on a global basis.

The network would not be a funding agency for crop protection research per se, but would serve more in the role of facilitator and promoter. It would do this by identifying contacts, providing liaison and serving as coordinator for crop protection meetings. Support functions might include conferences and workshops, training programs and technology demonstration projects coordinated through the IARCs and other institutions.

The annual budget for the network would be quite modest, perhaps in the range of U.S. $600,000 to $800,000. The staff, in addition to the leader would be mostly clerical. Short-time consultants and shared appointments could be used for specific projects and activities.

A Center-Without-Walls:

The second option considered by the panel was to create a Crop Protection "Center-Without-Walls". A Center-Without-Walls would be a logical step beyond the concept of a crop protection network in that senior scientist staff would be employed by the "Center" but they would not be housed in a building complex at a single location. The senior scientists would be provided the freedom to move to the sites where they would serve most effectively.

Crop protection research, by its nature, requires activities to be conducted in certain areas and at specific times of year. A Center-Without-Walls would not be constrained by a physical plant at one or a few locations. It could be truly global and thereby take advantage of existing resources and opportunities to address specific pest problems as they arise.

In addition to the advantage of flexibility, a Center-Without-Walls would permit a continuous adjusting of research activities to supplement existing IARC programs. This would allow them to be fully compatible with existing research programs. A Center-Without-Walls working in crop protection would allow specialists to effectively interface with the breeding programs, while developing new and appropriate technology to supplement technical advances in Integrated Crop Protection. It would allow specifically focused networking of projects to do research and to solve problems at the farm level through multiple links.

The staffing for a Crop Protection Center-Without-Walls should grow over a period of time to an optimum number of about 20 mixed discipline senior scientists. These scientists should have demonstrated professional competence and be of international recognition and reputation. The scientific staff of the Center might be located virtually anywhere in the world with the selected sites appropriate to their projects and to the Center-Without-Walls' mission. For instance some individuals may choose to have a portion of their time assignment at an institution of higher education in a developed country. They would travel from there to specific sites at designated times for specific activities. Other Center staff might choose to be

located at an International Center, but scheduled to work in a national program for specific periods on selected topics. This flexibility in assignments would be an essential aspect of a Center-Without-Walls by providing rich opportunities to address crop protection topics in ways not now possible.

The administrative structure for a Center-Without-Walls would resemble that of the network described above. It would have an officer-in-charge plus a small clerical and professional staff to service the needs of the scientists. Significant project support for individual project leaders would be necessary. Appropriate services for research, training and technology could be provided through contracts.

A project-based annual budgeting program could be used to develop personnel agreements for assignments for each scientist. Individual annual reports on accomplishments and plans for the subsequent year could be an effective administrative mechanism for research project oversight and direction.

Although some of the senior scientists at the Crop Protection Center-Without-Walls might be hired directly (perhaps on a five-year contract with annual review) others might be indirectly employed through a home institution through reimbursable agreements. Some of these agreements might be for 100% of a scientist's time. Other agreements might be for a smaller proportion of a person's time. Each agreement should be negotiated case-by-case between the Center-Without-Walls and the home institution. Reimbursable employment would provide the Center with staffing flexibility, and could prove to be a very attractive employment mechanism for some senior scientists that would not otherwise consider international employment.

A rough estimate of the annual cost of operating a Crop Protection Center-Without-Walls employing and supporting a senior staff of 20 scientists and providing overhead to participants/host institutions would be U.S. $10 million. This estimate includes direct administrative costs, salaries for senior scientists and support for individual research projects in crop protection. It also includes sufficient funds to reimburse the host institutions for some of the indirect costs (overhead) associated with project participation (see Box 1).

A Crop Protection Center-Without-Walls would be able to address many of the problems and constraints identified by the panel. It could establish policy to deal with the issues raised by the panel in its discussions. And it could provide the much needed collaboration with accountability for crop protection research, training and technology transfer for the CGIAR system, its partners and its clients (see Box 2).

International Center for Crop Protection Research:

The third option considered by the panel was the establishment of a fully fledged International Center for Crop Protection Research with an international mandate. Such a Center might be formed out of ICIPE or might be developed independently.

The mandate for an International Center for Crop Protection Research would necessarily stretch across commodities and regions. This would of course require negotiation with the existing Centers for firm agreements on responsibilities and assignments. This could prove problematic.

An International Center for Crop Protection Research would give heightened visibility to this important research area and would provide new opportunities to develop training and technology transfer programs in crop protection.

The administration and staffing structure of an International Center for Crop Protection Research would be similar to existing Centers with commodity or regional mandates. A staff of 20 to 30 senior scientists plus clerical, professional and maintenance staff would be required to operate the Center. Additionally, a tremendously large outreach program for research, training and technology transfer would be required to successfully meet the needs of the Center's crop protection activities. For this reason, it is anticipated that an annual budget for a fully operational International Center in Crop Protection Research would exceed U.S. $25 million.

The advantages of designating an International Center for Crop Protection Research would be seen as

heightened visibility for programs and a concentration of efforts. But these advantages would be partially off-set by difficulties in interfacing with existing programs at other IARCs. Collaborative projects would likely be difficult and overlapping missions would become complicated in some situations. The recruitment and retention of senior scientists might also be a continuing problem.

CONCLUSIONS

The proposed network of crop protection activities would go a long way in meeting the needs identified by the panel for crop protection activities in the CGIAR system. However, the panel felt strongly that more, if not all, of the proposed changes would be better and more completely addressed through the establishment of a Crop Protection Center-Without-Walls. Such a Center would provide programmatic flexibility to a degree not possible with a fixed location research Center. This is an important consideration for an institution charged with global responsibilities in research, training and technology transfer. A Center-Without-Walls would be an excellent way to provide needed leadership in crop protection, resolve the need for accountability, provide needed coordination of activities through planning and communication and assist in the development of policy impacting crop protection. It is for these reasons that the following recommendations are offered for further evaluation.

RECOMMENDATIONS

It is recommended that:

- The Consultative Group on International Agricultural Research establish a network of IARC crop protection specialists. The network would have the purpose of strengthening research coordination, collaboration and communication in IARC crop protection. It is further recommended that this network of crop protection activities be encouraged to evolve into a Center-Without-Walls. The timetable for this transformation might be over a 5 year period, allowing it to "ramp up" with senior staff hiring and project planning in research, training and technology transfer.

- The Technical Advisory Committee (TAC) of CGIAR consider fostering through the network an annual meeting of crop protection specialists from IARCs and partner institutions to promote communication and coordinated activities in crop protection research, training and technology transfer. A "summit meeting" would be a logical first step in establishing a network of crop protection scientists.

- Each International Center identify a crop protection coordinator to serve as a contact for individuals wishing to establish linkages in crop protection research, training and technology transfer.

- All Centers carefully review the emphasis now given to crop protection research as part of their on-going strategic planning process and provide senior scientists in crop protection opportunities to evaluate and plan new directions in crop protection research, training and technology transfer.

- TAC address the policy issues of crop protection research with a view to all of the components of Integrated Crop Protection. Special reference should be given to the appropriate use of pesticides in Integrated Pest Management programs in Third-World situations. A TAC evaluation should include not only the issues of pesticide safety and handling, but food safety, environmental impact and public perceptions of the uses of pesticides in contemporary agriculture.

BOX 1

CROP PROTECTION

CENTER-WITHOUT-WALLS

Sample Budget

20 Senior Scientists @ $250,000/yr. (Includes salaries, benefits, technical support, travel, equipment, etc., but does not include overhead costs which would be paid directly to the host institutions (at a negotiated rate) to provide needed services, space and support for research activities)	$5,000,000
Overhead to Host Institutions @ $50,000/ scientist year.	$1,000,000
Grants and Contracts.	$3,500,000
Center Administration and Management (includes conferences, workshops, and clerical services for center).	$500,000
TOTAL	$10,000,000

BOX 2

CROP PROTECTION
CENTER-WITHOUT-WALLS

Example Project

The following example has been developed to describe how a single project in the Center-Without-Walls might be organized.

A senior scientist is employed by the Center on a 5 year (annual, renewable on merit review) research project to investigate and develop components of an IPM program for maize. The work time- table the first year includes six months at CIMMYT in Mexico to develop the targeted pest problems, evaluate germplasm with CIMMYT scientists and review tropical maize production practices as they impact crop protection. Two months are then allocated for laboratory and literature research at CABI's Commonwealth Institute for Biological Control in Ascot, England and to plan a collection trip for biological control agents in appropriate locations in South America. The collection trip is then the final four months of the first year.

The costs of supporting the activities are directly reimbursed to the host institutions (CIMMYT and CABI) as indirect costs (overhead).

The second year timetable includes 4 months at a research laboratory cataloging and storing the biological collection for future needs. This might be at a university where facilities, space and scientific support is readily available for the tasks.

The next 8 months would be spent back at CIMMYT conducting field tests of biological activity with selected isolates. International movement of the agents would be facilitated by the network of support already formed (CABI and the university).

The third year would focus on integrating the biological control tactics with the major production practices. This might be at IITA, in West Africa if that location was chosen as most suitable.

Thus, this sequence of research follows the normal progression of investigation, expansion and integration with a mix of Centers, research institutions and locations, each facilitating research activities at key times. The opportunities to interact with all crop disciplines is a big plus and the flexibility to move to the next step at the appropriate location is a unique advantage of the Center-Without-Walls concept.

As certain needs arise (research topics) or opportunities present themselves (training, workshops) the Center would provide support as grants, contracts or other resources to enhance and facilitate project activities.

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The Study Director takes full responsibility for any errors or omissions contained in this document.

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