CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

An Evaluation of the Impact of Integrated Pest Management Research at International Agricultural Research Centres

A Report from
TAC's Standing Panel on Impact Assessment (SPIA)
formerly known as the
Impact Assessment and Evaluation Group (IAEG)

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
October 2000

This document comprises:

(a) Extract from *Summary of Proceedings and Decisions*, CGIAR International Centers Week, 1999, Washington, DC, USA

(b) Foreword by Hans Gregersen, Chair of the CGIAR Impact Assessment and Evaluation Group (IAEG)

(c) Report of the Study – An Evaluation of the Impact of Integrated Pest Management Research at International Agricultural Research Centres

Consultative Group on International Agricultural Research - CGIAR

From: The Secretariat December 1999

CGIAR International Centers Week
October 25-29, 1999
Washington, DC

IAEG Study on the Impact of Integrated Pest Management Research[1]

Hermann Waibel of Hannover University provided highlights of IAEG's study on the impact of research on integrated pest management. He noted that research on IPM has been underway in all Centers for a long period, and that the technological paradigm of IPM is dominant and there is also increasing appreciation given to treating IPM in a social science context. The future of IPM is heavily dependent on developments in biotechnology that will determine the nature of future partnerships. Finally, the study clearly show that CGIAR's investments have been profitable, and that even in the long term, the rate of return to investment in IPM research is in the magnitude of 15 to 40 percent.

Plenary Discussion

The Group endorsed the IAEG's preliminary reports on the CGIAR's impact on poverty eradication, food security and environmental protection, and urged the IAEG to move quickly into the next phases of these studies. IAEG was commended for its work on the impact reports, which are seen as a significant step forward. Special thanks was given to Hans Gregersen for his leadership in directing the IAEG's solid, scientifically rigorous, and transparent studies to produce information on CGIAR impacts. Centers are playing a key role in the impact assessment activities, and both IAEG and the Centers are benefiting through the interactions.

Members praised the studies for including the viewpoints of NGOs, multi- and bi-lateral donors, and the private sector. Members also agreed that the linkage of IAEG's evaluation work with TAC's overall priority setting and overall evaluation is a positive development.

[1] Extract from *Summary of Proceedings and Decisions*, CGIAR International Centers Week 1999, Washington, DC, USA.

CGIAR Secretariat • Mailing Address: 1818 H Street, N.W., Washington, D.C. 20433, U.S.A. • Office Location: 701 18th Street, N.W.
Tel: (1-202) 473-8951 • Cable Address: INTBAFRAD • Fax: (1-202) 473-8110 • E-mail: CGIAR@cgiar.org or CGIAR@worldbank.org

Consultative Group on International Agricultural Research – CGIAR

Document No.: ICW/99/08/c
Distribution: General
Date: September 30, 1999

International Centers Week 1999
October 25 - 29
Washington D.C.

Reducing Poverty through Cutting-edge Science

Evaluation of the Impact of Integrated Pest Management Research at the IARCs

The attached report was prepared by Prof. Hermann Waibel of Hannover University on behalf of IAEG. It will be discussed under the Agenda Item 2: *Confronting Poverty: The Critical Role of Science*, and should be read in conjunction with the *Report on IAEG Activities* (ICW/99/08/a).

This report will be discussed in plenary session. Prof. Hermann Waibel will introduce the report prior to discussion and decision-making by the Group.

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IAEG Foreword

Integrated Pest Management accounts for a considerable share of the allocation of research resources in the CGIAR, and has been credited with a number of successes, such as the control of the cassava mealy bug, the use of IPM in rice production in Asia, and the control of the Andean Potato Weevil. The IAEG selected IPM as a suitable theme around which to conduct a study on the evaluation of its impact. Informal discussions with Members of the CGIAR, as well as Centre Directors, indicated a high level of enthusiasm about the choice of the theme.

The IAEG was fortunate to be able to draw on Prof. Hermann Waibel to conduct this study. Prof. Waibel is a recognized international expert in the field of evaluation and impact assessment of IPM. In our communications with the Centres, we were greatly assisted by the members of the System-wide Programme on IPM. As AVRDC and ICIPE are both active members of this Programme, their activities were incorporated in the scope of this study also.

Clearly, Dr Waibel faced a Herculean task in a very short period of time. He essentially produced his study results and conclusions in six months of part-time involvement. The result of these efforts is a detailed multifaceted picture of IPM activity in the Centres. His assessment provides a great many useful insights, both for Centres as they move forward in this area, and for the System as a whole as it contemplates the future direction of the overall CGIAR thrust in IPM and the funding of the associated activity.

Dr Waibel first goes through a logical progression of (a) clarifying definitions and the questions being asked, (b) setting out a conceptual and methodological framework, (c) describing the IPM activities within the System, and (d) evaluation of the impact and rate of return of investment in IPM research. A logical argument is given as to why an overall rate of return study could not be carried out for CGIAR research on IPM in isolation, although he accepts the value of carrying out project-specific case studies of such rates of return. Throughout the report, he stresses the need to assess the impacts of IPM in the broader context of overall crop-management research. In looking at the existing IPM research rate of return studies – which uniformly achieve high rates of return - he warns that:

> *These examples make clear that a high rate of return in pest control is not an indicator of successful crop/pest management, it can also be the opposite. If investments in IPM are designed to prevent pest crisis these invariably become joint crop-management research investments. Trying to single out the share of IPM from this combination would not make much sense. The objective of public crop science research clearly should be to optimize the entire crop-management system rather than to maximize the share of IPM. On the other hand, the rates of return which can be obtained from crop-management research that include IPM components can be interpreted as a lower band. IPM helps to reduce negative externalities of pesticides on humans and the environment. These effects are often excluded from economic analysis.*

Dr Waibel adopts a multifaceted approach to assessing the efficiency and effectiveness of IPM work in the centers and links these results to an overall assessment of the impacts associated with IPM activities. This approach involved developing different classes of indicators of impact.

Specifically, in addition to considering the history of development of IPM work in the Centres, he looked at:

- the results of participatory self-assessment of their impacts by the Centres;
- the opinions of clients and partners;
- the quantity and type of published materials coming out of the programs (related to impacts on science);
- the quality and validity of the existing economic rate of return studies.

From this four stage assessment, Waibel reaches the following conclusions:

- "There is little doubt that past investment in IPM was profitable....(although) studies of failures could not be traced".
- At the same time, he continues that "it is likely that IPM in the context of crop-management improvement will have lower rates of return.... because success very much depends on the existence of an effective model. He suggests that these lower rates of return will still be "at a level not achieved in many other investments.... probably the long-term rate of return to investment in IPM is in the order of magnitude of 15 to 40% rather than the more than 100% found in pest crisis cases".
- Additionally, Dr Waibel suggests that the past rates of return to IPM research may be conservative, considering that they did not include environmental losses (particularly health-related) avoided due to the use of fewer pesticides and insecticides.
- The level of activity in the Centres is growing and is taken seriously by the Centres and their partners, implying a belief among these parties that the impacts are real and significant.
- The technological paradigm of IPM is still dominant in the Centres, but the move is towards focusing more on the "M" in IPM and thus on social science issues that lead to questions regarding farmer adoption and mechanisms to speed up the adoption of proven technologies. Dr Waibel points out that the lag between research and widespread adoption is critical in determining the level of rates of return that can be expected.
- The work of the Centers is widely accepted and used by peers in the scientific community; the quality of the research is good, implying significant impact on the scientific community involved in this type of work; ("the high professional quality of IPM research seems to be beyond any doubt").
- While the work of the Centres in IPM is well known by peer scientists, it perhaps is not as well known by those partners involved in implementing field programme; similarly, with a focus on technological issues, not enough is being done to understand, through research, the problems of implementation and adoption.
- Partners and clients in general believe that the CGIAR Centres have important impacts, but, as would be expected, they also have suggestions as to how such impacts could be strengthened.

In the final part of the study, Dr Waibel puts forth some questions and suggestions for future activity in the area of IPM. With regard to recommendations, Dr Waibel has three:

1. more economic case studies of the impact of science-based, public-sector IPM technologies should be carried out and the System-wide Programme on IPM could serve as the focal point for such activity;
2. the System could well devote some of its resources to further advance the methodology for doing such impact assessments; and
3. increasingly the IPM impact assessment of the Centres should include the inputs provided by partners in extension, be they NARES or NGOs.

Dr Waibel based his analysis on existing documentation and findings through a questionnaire and interviews. While he reviewed literally thousands of Centre publications on IPM, only a few of them related to impact assessment. This is an important lesson for the System. Dr Waibel's report also documents the strong links of the CGIAR with NARS, NGOs and the private sector in the field of IPM.

The IAEG thanks Dr Waibel for an interesting, broad-based, yet thorough assessment of the efficiency and effectiveness of IPM activity in the CGIAR. As he points out, with more time – and over time – there are a lot of additional questions that need to be addressed; and the Centres need to start now to set up the monitoring and evaluation systems that will let them better track the impacts of IPM research in the broader context of their overall crop-management programmes.

Hans Gregersen,

Chair
CGIAR Impact Assessment and Evaluation Group

September 1999

An Evaluation of the Impact of Integrated Pest Management at International Agricultural Research Centres

Hermann Waibel

IAEG Secretariat

September 1999

Acknowledgement

This report would not have been possible without the cooperation, assistance and patience of a number of people.

Foremost I would like to thank all the Centre Directors for allowing their researchers and administrative staff to spend their sparse time on filling up questionnaires, answering Emails and preparing lists of literature in relation to this study. I am grateful to the champions of integrated pest management and the people behind the scenes who took the effort to participate in this study. I especially thank them for their patience when requests to resend material via Email were posted as a result of several 'black holes' in the Hannover cyberspace link.

My thanks are also due to the representatives of multilateral and bilateral organizations, private sector companies and non-governmental and other organizations for being available for telephone interviews and offering their ideas.

I am especially grateful for the guidance of Guido Gryseels from the IAEG office in Rome and Hans Gregersen, Professor at the University of Minnesota and concurrently chairman of the Impact Assessment and Evaluation Group (IAEG) of the Consultative Group on International Agricultural Research. They took the risk of an 'investment' with a considerable degree of uncertainty. Likewise, I appreciate the suggestions and the materials that were made available by the other members of the IAEG at a meeting in July 1999 in The Hague.

Last but by no means least, I am most grateful to the two members of the Institute of Economics in Horticulture at the University of Hannover: Bernd Hardeweg who ran some spreadsheet simulations with an extremely low response time and Diemuth Pemsl who was 'punished' with all the number crunching. She was much more than just an excellent research aid and came up with some really good suggestions.

With all the help extended to me, I am tempted to cite John Dillon and say: "all remaining errors are of course theirs". As time was extremely short – like always – there is no point in further talk about 'labour pains', just look at the 'baby' and hope that with the help of others it develops.

Hermann Waibel
Institute of Economics in Horticulture
University of Hannover
Herrenhaeuserstr. 2
30419 Hannover
Tel +49 511 762 2666
Fax + 49 511 762 2667
Email : waibel@ifgb.uni-hannover.de

September 1999

Acronyms

AVRDC	Asian Vegetable Research and Development Center
BCR	Benefit cost ratio
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CIP	Centro Internacional de la Papa
CRBP	Centre Régional Bananiers et Plantains, Cameroon
FAO	Food and Agriculture Organization
GTZ	Gesellschaft für Technische Zusammenarbeit
IAEG	Impact Assessment and Evaluation Group
IARC	International Agricultural Research Centres
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICIPE	International Centre of Insect Physiology and Ecology
ICLARM	International Centre for Living Aquatic Resources Management
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INIBAP	International Network for the Improvement of Banana and Plantain IPGRI
IPGRI	International Plant Genetic Resource Institute
IPM	Integrated Pest Management
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
MSV	Maize streak virus
MV	Modern varieties
NARS	National Agricultural Research Systems
NARES	National Agricultural Research and Extension Systems
NGO	Non-governmental Organization
R&D	Research and development
SP-IPM	System-wide Programme on Integrated Pest Management
TAC	Technical Advisory Committee
TV	Traditional varieties
WARDA	West Africa Rice Development Association
WB	World Bank
WRI	World Resources Institute
WWF	World wide Fund for Nature

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Executive Summary

The approach taken in this study was to go through a four-stage assessment in order to build up a body of evidence on the impact of IPM research at the International Agricultural Research Centres. Both 'soft' and 'hard' indicators were used based on:

- a participatory self-assessment process by the respondents from the Centres,
- analyzing the quantity and type of published materials
- subjecting the perceptions expressed by the respondents from the Centres with the opinions of their clients and partners
- a review of a sample of economic case studies on IPM.

The first positive result is that work on IPM continues to be carried out in all Centres although little funding comes from the Centres' core budget. IPM at the Centres is definitely more than just a fashionable catchword to attract donor funding and the lists of publications on IPM underline the high profile of this subject area. The high professional quality of IPM research seems to be beyond any doubt. Scientists working in IPM have taken the original idea of the 'integrated control concept' seriously and have put their efforts into providing alternatives to the plant-protection products of the private sector, as shown by the high emphasis given to resistance breeding and biological control.

There is a dominance of the technological paradigm of IPM but increasing appreciation is also given to the term 'management' in IPM. However, the role of agricultural and environmental policies, which can either precondition an environment conducive to IPM adoption or be an impediment to its spread, is not yet sufficiently recognised by the Centres.

The future of IPM is perceived as being very dependent upon the developments in biotechnology that will determine the nature of future partnerships. In this regard, there is a tendency for Centres to increasingly assess the plant-protection products of the private sector as complementary to the development of 'their' IPM technology rather than as alternatives as in the past.

There is little doubt that past investment in IPM was profitable. Whenever economic impact studies have been conducted similar rates of return to those produced in the studies on other agricultural research investment have been shown. However, investments in IPM are often of a 'fire-brigade nature'. IPM is called in when farmers are confronted with a crisis situation – either the result of pests or pesticides – and private-sector technologies have either failed or are unavailable. Therefore, what is treated as a benefit in investments that aimed to overcome pest crises are actually off-time externalities of misguided interference in the past. The pest and pesticide treadmill helps to 'inflate' the rate of return on pest control.

Investments in pest control must be treated differently from investments in pest management. Hence, a high rate of return in pest control must not be equated with successful crop and/or pest management. The opposite can also be true: If pest control is highly 'profitable' the cropping system could be in a bad shape. The yardstick for measuring the true economic impact of IPM can, therefore, not be limited to calculating the rate of return in a static economic efficiency concept. It needs to capture the feedback mechanisms that human interference, such as pest-control actions, produce in ecosystems and the interaction between environment and economy.

The analysis led to a number of 'paradoxes' that could not be fully explained:

- Increased pesticide use and at the same time increased losses from pests for many of the world' s crops. Why do crop losses go up in relative terms despite more and better pesticide use?
- The continued dominance of component research in IPM relative to 'management' in a social science context.
- Why is IPM not at the centre of the discussion on private- public-sector partnership in relation to agricultural development and food production while the current generation of biotechnology is in the field of pest management?

- The lack of appreciation given to the linkage between IPM adoption and the wider context of agricultural and environmental policies.

On the basis of the analysis three recommendations are made:

- To carry out more economic case studies on the impact of science-based, public-sector IPM projects in order to advance the methodology of IPM impact assessment. There is a need to take impact evaluation beyond short-term income effects and to also include an assessment of the natural resource implications and the long-term effects on the farmers' innovative and problem-solving capacity, including the institutional implications.
- To advance the conceptual basis of crop-loss assessment in order to generate a better understanding of the factors that affect yield, and yield variability, and establish a link between crop loss, IPM and food security based on good science.
- To formulate a System-wide IPM strategy in order to establish a clearer vision about what can be expected from IPM to make it clearer to donors, clients and partners what type of IPM products they can obtain in the future.

1. Background and rationale

Integrated Pest Management (IPM) has become one of the most frequently used catchwords in international development. Among stakeholders in crop protection – be they in research or extension, public or private institutions, donors or recipients of development assistance – there is unlikely to be anyone who would not claim to support IPM. This raises the question as to why there is a need to evaluate a concept that everyone is in agreement with. If it were understood that IPM is *the* method of crop protection why would one have to ask what its impact is? This is like asking why protect crops. The only rational question is how much crop protection, i.e. what proportion of resources should be devoted to protecting crops as opposed to just producing them.

Of course matters are more complex. There is widespread disagreement over what IPM really is, what its goals should be and how it should be used. A recent OECD publication has come up with 21 definitions of IPM (OECD 1999) and there are probably many more in existence. There is little doubt, however, that IPM was developed as an alternative to the over-reliance of crop protection on chemical pesticides (Stern *et al.* 1959) and as a concept to facilitate sustainable intensification of agriculture. Consequently, the assumption can be made – which has been proven by many studies – that leaving pest control technology entirely to the private sector will not lead to a socially desirable outcome. This is the why governments and donors invest in public-sector IPM. The International Agricultural Research Centres (IARC) of the Consultative Group on International Agricultural Research (CGIAR) are important players in facilitating the development and diffusion of IPM which serves public interests in the context of welfare theory, i.e. maximizing net social welfare.

By taking this as a base it, is possible to broadly define what is included under the IPM activities of the Centres as being *any research and development efforts by the Centres that aim to bring pesticide use towards their social optimum.* Similarly, IPM in the context of development projects is understood as pest management activities in agricultural projects that are not necessarily specific IPM projects.

Although there are projects, which are clearly labelled as IPM, there are also activities that only address one component of IPM, such as classical biological control. In addition there are IPM activities, which are carried out in conjunction with other programmes such as resistance breeding.

The overall thrust of this study is to provide evidence for the efficient use of the public funds invested by the Centres in IPM.[1] In practical terms, this means carrying out a cost-benefit analysis showing the rate of return in such investments. However, the value of such an exercise could be queried given that past analysis of the costs and benefits of research and development (R&D) in agriculture show an average rate of return of some 80% (Alston *et al.* 1998). Of course one could ask why the rates of return on investments in IPM should be any lower given IPM's potential economic, environmental and health benefits. Part of the answer is that while IPM continues to draw donor attention, many actors are cashing in on IPM, including the pesticide industry, which markets its plant protection products (mainly pesticides) under the banner of IPM. Therefore, impact assessment can help to judge IPM by its effect rather than by its 'name'.

Also, if support for public IPM is to be sustained then analysis of its performance is needed for reasons of accountability, and also to draw lessons from case studies and other available evidence. This will allow a judgement as to whether research on IPM at Centres is moving in the right direction and whether the approaches followed are likely to meet the challenges of the 21st century.

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[1] For the purposes of this report, the Asian Vegetable Research and Development Centre (AVRDC), Taiwan and the International Centre of Insect Physiology and Ecology (ICIPE) are included with CGIAR Centres as they are both members of the System-wide Programme on IPM.

These questions can be answered only partially in this study because of limitations in quantifying the impact of IPM activities, especially those not directed at implementing IPM in the field. In carrying out this study, the basic decision that had to be made was whether to go for maximum depth and minimum breadth or minimum depth and maximum breadth. The first option would mean carrying out an in-depth case study for one or two selected Centres while the latter would entail an overview of all Centres IPM research. It was decided to take the latter option, as this would allow the identification of relevant questions for subsequent follow-up by case studies.

It is difficult to judge the level of success of IPM activities that aim to provide the basic knowledge or understanding that will allow others to carry out IPM field projects more effectively. Similarly, if Centres have trained the staff of National Agricultural Research Systems (NARS) in IPM it is not possible, in the context of this study, to identify the outcome of such knowledge transfer or the level of productivity increase that resulted.

As this study was carried out under rather severe time constraints a pragmatic approach was chosen. The basic principle was to request Centres to participate by completing a questionnaire and providing lists of published materials. Completing the questionnaire allowed the Centres to describe the nature and success of their IPM activities, and their future plans in this field. While the published material was used to find evidence of the extent to which IPM-related research resulted in follow-up activities and to identify possible patterns in IPM development. In addition, selected outstanding cases were highlighted and a further study made of these to show whether or not these cases studies could be used to illustrate the extent of the economic benefits resulting from Centres' research and development in IPM. A framework was used that attempted to allocate different levels of evidence to the different IPM products.

It is important to make clear that this study was not carried out in order to compare the work of Centres on IPM, neither would this have been possible within the available time. For this reason, not all the material of all Centres is included in the report. The purpose of the study was to draw an overall picture of IPM within the CGIAR system without going into specific details on any individual Centre.

Some thoughts on the methodology of impact assessment for IPM

In many cases, impact assessment of agricultural R&D activities is done in the form of cost-benefit analysis. This is reasonable because R&D in the IARCs requires public investment expenditure, which carries opportunity costs. There are many studies that have attempted to measure rates of return to agricultural R&D since the seminal work of Griliches (1957).

For the CGIAR Centres, the rates of return analyses of Evenson and Flores (1978), which assessed the benefits of modern varieties (MV) over traditional varieties (TV) for rice research in Asia, are probably among the most prominent. The basic assumption there was that "extension programmes in general do not produce much new technology. However they enable farmers to adopt and screen potentially valuable new technology" (Evenson and Flores 1978). The authors also observed from their econometric analysis that "interestingly, the effect of MV is strongly interactive with indigenously-produced technical knowledge" (Evenson and Flores 1978). This analysis shows that even with seeds, the impact of technology is not mono-causal and straightforward. A recent study of Alston *et al* (1998) pointed out other measurement issues and problems:

- How to correctly estimate the percentage of research-induced reduction in production costs?
- How to estimate the size of the industry affected by the R&D innovation?
- How to estimate changes in the supply of inputs induced by R&D?
- How to estimate when benefits from adoption commence, i.e. what is the time lag between the introduction of an innovation and its adoption? ?

Both underestimation and overestimation of costs and benefits from agricultural research can occur. The market model, which has been the dominant approach to evaluating the impact of agricultural R&D, can lead to an overestimation of the benefits if a large proportion of the produce is not marketed or if poor infrastructure results in high transaction costs. Underestimation can occur if R&D produces positive environmental and natural resource management benefits, which have not been included in the market effects. On the other hand, technology can also have negative effects on the environment and natural resources, the omission of which leads to the true costs being underestimated.

In addition to these methodological problems there has recently also been criticism from some social scientists who consider the linear causality assumption which underlies the classic approach to impact evaluation as highly questionable in regard to agriculture. For example, Jiggins (1999) states:

"If agriculture is viewed as an open non-linear system, it then possesses an irreducible ambiguity or indeterminacy in terms of quantitative solutions (values). Farmers in this view, approach their environment in ways captured by the metaphor of a 'dance' in which actors are locked into a reciprocal engagement with, or adaptive co-structuration of the institutional relationship among people, agriculture and ecosystem. In this view, decision-making is seen as performance within an inherently unknowable spatial and temporal dynamic in which trend is the key trigger to management. There is a growing body of scholarship and practice which sees evaluation of the 'dance' as best handled by participatory processes and interactive evaluation methods"

As Jiggins (1999, p. 27) concludes from this analysis:

"Agriculture is a problem of non-linear system management which requires that evaluation methods be based on constructivist (rather than positivist realist) epistemology. This is not to exclude objective measurement and instrumentation but to locate the use and outputs of these within another process and interpretative frame..... It should be noted that the objective of evaluation changes in this scenario, from an external 'third eye' assessment of performance as if activity could be managed by controlled design, towards involvement in assessment processes that seek to improve situations through shared learning about how to move in the direction of a moving target [which is sustainability]. The focus also shifts from an emphasis on cause and theories of, to an emphasis on reasons and meanings and ideas about."

The above views on evaluation and impact assessment are mentioned here as they have some relevance to this study, mainly for two reasons.

- The task is to evaluate a system rather than a clearly defined project; hence the assumption of linearity and causality cannot be maintained throughout.
- IPM has some special features that need to be considered when interpreting results as a 'good' in the economic sense.

What makes IPM complex?

IPM is a knowledge-based technology that needs to be adapted to specific locations and situations. It cannot be packaged and sold like seeds, fertiliser and pesticides. Hence a quantitative analysis of its costs and benefits requires exact data on the benefits per unit, its diffusion, and variables such as the number of farmers trained and the quality of the training. This information is not available on a worldwide scale for the mandate crops of the Centres. In addition the problem of defining IPM makes it difficult to measure its diffusion.

IPM means different things to different stakeholders. Most notably, the adoption of the concept by the commercial sector as a means to market its products and to improve its 'green image' has complicated the issue. While for the public sector a definition of IPM based on the welfare theory can be used, this cannot be assumed for the commercial sector where a concept of 'rationalized' or 'farmer first' IPM has been defined. The chemical company Novartis for example has defined the aims of IPM as follows (J. Brassel, personal communication, September 1999).

"to keep pests below yield reducing levels and secure sufficient income by using safe and environmentally friendly [pesticide] products included in a broad technology basket from which farmers can choose according to their needs. Farmers are assisted in their decision-making process through [company] farmer-support teams that aim to help the farmer to choose from the 'technology basket' and to apply technologies in line with 'rationalised sustainable' IPM. A technology basket is all available technologies for pest management for a crop, e.g. cotton, including modern chemical, biological and mechanical technologies."

This definition shows that the commercial-sector IPM concept places farmers – who companies naturally consider as their clients – at the centre of their concern. Society as a whole, however, is not mentioned in this definition. Therefore, we are confronted with at least two IPM goods from an economic point of view: public and private. Whereas ideally 'private IPM' helps farmers to make rational (profit-maximizing) resource-allocation decisions, 'public IPM' aims to strike a balance between producers, consumers and the environment in the context of sustainability. This differs from, for example, commercial seeds, particularly those from genetically modified plants, as these are clearly private goods targeted for market crops. Farmers pay for the seeds and in the case of genetically modified plants, also a technology fee. Seeds for non-market crops, i.e. those where a royalty cannot be claimed because seeds are freely grown or exchanged or where the market is too small for commercial varietal improvement and seed production, are supplied by public organizations at a price below their marginal cost. In this example there are two distinct markets. In the case of IPM, however, the situation is different as the private sector can only charge royalties through the sale of other plant-protection products that are considered private goods.

Given the complexity that exists with the 'good' IPM, restricting the study to the use of the market model to estimate costs and returns from the Centres' R&D IPM activities would fail to include the true effects of IPM. Consequently, trying to establish an overall rate of return for CGIAR investment in IPM would be meaningless. The general problems in using the market model for impact assessment are given above. However, there are also other reasons why conducting an overall cost-benefit analysis of the Centres IPM activities is not advisable. These are as follows.

- The major thrust of the Centres is in developing technologies whose successful field application depends on the right extension partners. As this demands the inclusion of investment in extension and farmer-driven innovations, apportioning costs would be arbitrary.
- IPM is notably different from the classic seed technology of the Centres. While seeds can be likened to 'hardware', IPM is 'software' that needs to be fine-tuned for application in specific locations. In this process, the Centres usually provide the basic knowledge and tools but rarely the exact specifications. This is done by extension organizations in cooperation with farmers.
- Because IPM is a multi-stage product, it is not possible, within the scope of this study, to separate the effects of R&D from those of extension. While the classic seed technology is a turnkey system, where the role of extension is mainly to speed up the diffusion process, IPM is an intermediate product that must be finalized by its user. For example, the role of pesticides in causing pest resurgence and the role of beneficial organisms in keeping pests in balance are researchable issues. However, before the results can be applied, location-specific experiments are needed. This requires resources that must be accounted for in cost-benefit analysis.
- To limit the impact of IPM to the study of the effect on crop markets is likely to underestimate their true welfare effects. Public-sector IPM goes beyond rational pesticide use (also referred to as rational IPM by the chemical companies) as it is also concerned with reducing the side effects of pesticides. As shown by many studies, (e.g. Pimentel *et al.* 1993) the side effects of pesticides are often difficult to value in economic terms because of unspecified cause and effect relationships and the nature of the goods and services they affect. For example, fatal

poisonings and the chronic health effects of pesticides are not only difficult to establish but also cause methodological problems of economic valuation because of the ethical dimension that needs to be considered in such assessments.

To conclude this conceptual and methodological discussion on impact assessment it is clear that a comprehensive assessment of the impact of IPM must try to place the results of available economic evaluation into a broader framework of indicators. However, these indicators must be able to qualify the results found in case studies of Centre-initiated field projects on IPM where an economic analysis was performed. Only then can the results be used as arguments for adjusting the rate of return.

2 Conceptual framework of the impact assessment

The concept

The analysis of evidence on the impact of the Centres' investment in IPM is based on the following hypothesis:

"If field projects on IPM show success in terms of economic efficiency and in improving environmental and human health conditions, and if the outputs of the Centres' IPM activities are being demanded by the implementers of IPM field projects, i.e. their clients and partners, then the investment of the Centres in IPM R&D is likely to be justified".

As discussed in the previous section, to come up with an overall rate of return on the Centres' investment in IPM is not possible nor would it be sufficient to capture the true impact of IPM. Consequently, the procedure followed in this analysis is to assess the linkages that exist between the Centres' R&D activities in IPM and their immediate outputs. To start with the most direct output, basically Centres produce research results and expertise (Figure 1). Research on IPM is expected to be conducted following internationally accepted scientific standards and to produce results that are publishable. At the same time, they are expected to increase knowledge and understanding on relevant problems that inhibit the adoption of IPM.

The quality of publications on IPM is often judged according to internationally recognized 'journal impact points' associated with the journal. In general, the immediate output of a researcher is publication, his/her performance is judged on that scale and his/her professional reward is a function of that scale. Publications are the researcher's main incentive and, therefore, his/her efforts will be directed towards that end. However, this is an incomplete measure of impact, as criteria are being used in this index that do not necessarily value, for example, the problem-solving potential of science.

Research results may also differ with regard to their impact on the relevant professional societies. While new methods may help to make IPM implementation become more efficient, research that challenges conventional wisdom provides the ground for future efficiency gains. The most outstanding research results may affect paradigm shifts inside and outside the relevant professional society that may lead out of 'path dependency'. However, this is difficult to judge and can only rarely be related to a specific scientific programme or research activity. It becomes obvious that the differentiation of research outputs with regards to IPM products is difficult. Nevertheless, the clients can use any IPM-related material that has been published by the Centres and partners to plan and implement their IPM field projects. Such use is an indicator of success.

Clients and partners include all the other organizations and stakeholders promoting public sector and private sector IPM. The most direct partners of the Centres are the National Agricultural Research and Extension Systems (NARES). Multinational organizations, such as the World Bank and several directorates of the European Commission, also play an important role as partners in IPM projects, Among the multinationals which implement together with national partners, rather than fund IPM projects in developing countries, is the Food and Agriculture Organization (FAO). FAO is responsible for the Global IPM Facility, a multi-donor body that promotes the farmer field school approach to IPM. As the Global IPM Facility relies on the scientific base provided by Centres for its projects, which aim to improve farmers' understanding of agro-ecosystems, FAO is an important partner. Many bilateral organizations, such as US-AID and the German GTZ, also cooperate with Centres and Non-governmental Organizations (NGOs) are increasingly becoming clients of the Centres' IPM technologies and expertise.

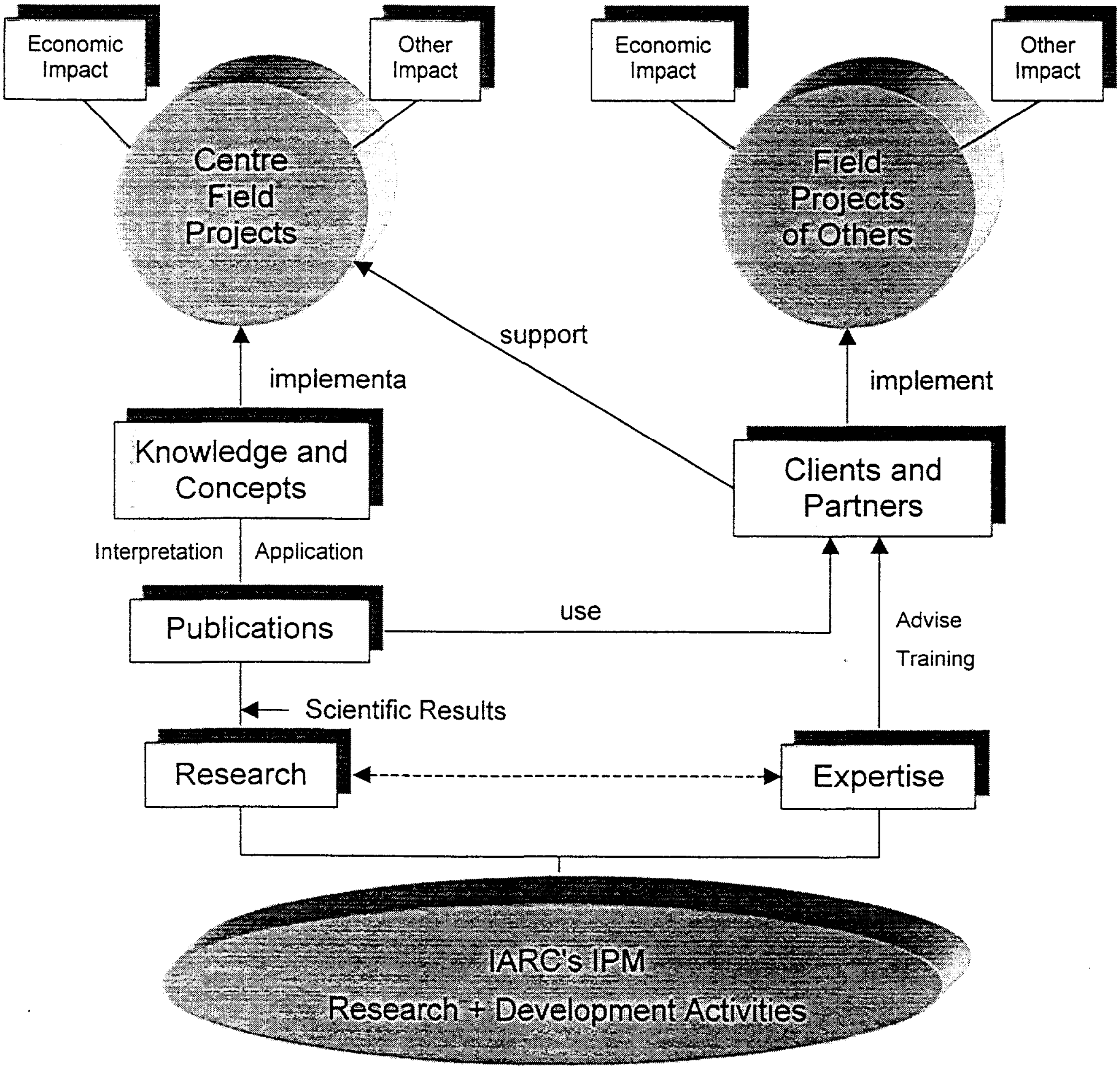

Figure 1. Concept of IPM impact assessment

The chemical companies are special partners (rather than clients) in the Centres' IPM initiatives. Their major thrust is the sale of pesticides and genetically modified plants but they have also adopted the concept of IPM. Although this is notably different from the IPM concept of the non-commercial stakeholders (as explained in section 1), the importance of the linkage between the Centres and the commercial sector is probably increasing as biotechnological innovations further advance.

The description of actual and potential clients and partners shows that there are potential 'buyers' of the Centres' IPM research results and expertise. Hence, the external demand for the Centres' IPM publications as an indicator of success. In addition, scientific publications by Centres on IPM can be processed into knowledge and concepts for use in Centre-managed IPM field projects. These in turn can be subjected to cost-benefit and multi-criteria analysis for impact.

Centres' second main contribution to advance IPM is through their staff, who advise partners and clients in the design and implementation of IPM projects. Centre staff can also train staff of other organizations on technical and methodological issues, and advise on technical and policy recommendations. This can help clients and partners to more efficiently implement their IPM projects. At the same time, clients and partners both from the public and the private sector can support Centres in their efforts to carry out field projects on IPM. The fact that such support is given, and the extent to which it is being provided may be used as an indicator of success.

The approach taken by this study is to assess, as indicators of impact, the strength of the links between research activities and Centre-implemented IPM programmes, and the demand and reactions of partners and clients to the Centres' IPM research output and expertise. Whenever quantitative evaluations are made, including the calculation of rates of return, the identified strengths of the links can be used as an indicator of the validity of the quantitative case-study results.

Data collection procedure

The study was performed as a desk study. No visits to the Centres were undertaken and all contacts were by Email or phone. In addition to published literature, data were collected from the Centres as well as from their clients and partners.

Centres provided three sources of information:

- reprints of publications and evidence of economic analyses of IPM field projects
- a list of the publications with relevance to IPM
- a questionnaire giving information on the history, and the present and future situation of IPM at the Centres (Appendix 1).

The questionnaire was complemented by a description of the approach taken in the study. The Centres were informed that their IPM-outputs would be organized around different types of IPM products and attributed to different levels of evidence (Table 1). Centres were asked to allocate their IPM initiatives according to the defined IPM products and provide evidence based on the defined level. The timespan was Centre-specific, i.e. starting with the beginning of IPM activities as defined by the Centres.

For the analysis the scheme conceptualized in Table 1 could not be fully maintained because it turned out that the distinction among the defined IPM products is not always clear, e.g. with 'paradigm shifts' and 'methodological improvements'. Nevertheless the scheme prompted the respondents to think of activities they would not have immediately associated with IPM, for example: training, building awareness and policy change. The allocation of IPM product to level of evidence also proved problematic as the international journal impact index has been criticised as being unsuitable for judging research quality (Seglen 1997). However, this did provide a first step in ranking research output based on internationally recognized, albeit not unproblematic, standards.

On the other hand ranking was easy in those cases where Centres had carried out economic evaluation of field programmes. A good example was the impact study of the International Institute of Tropical Agriculture (IITA) on cassava mealy bug published in the American Journal of Agricultural Economics (Noorgaard 1984). Publication of IPM impact studies in such high quality journals can be assumed to be of higher validity than studies only published in crop protection literature or in internal reports and which have not been subjected to a formal economic analysis. If IPM field programmes are not subjected to economic evaluation then the level of evidence can be regarded as low.

For sources external to the Centres, data were collected through telephone interviews with representatives of organizations particularly active in the field of IPM and which, it could be assumed, are interested in the IPM outputs of the Centres. Due to limitations in time, not all organizations and partners could be contacted. However, it is believed that a fairly representative sample was obtained of multilateral and bilateral development organizations, NGOs and the commercial sector. Questions were sent to the respondents prior to the interviews, which were then taped and transcribed.

Statements made by respondents were regarded as being the opinion of representatives from the respective organization and not necessarily of the organization itself, which may not have an official opinion on IPM. The information was used to assess the strengths of the links between Centres and their client and partners, in terms of IPM research output and expertise (see Figure 1).

In addition, information was obtained from impact studies not specifically dealing with IPM. Most notably here is the review of Alston *et al.* (1998) and the 1994 review of the Impact Assessment and Evaluation Group (IAEG).

The International Service for National Agricultural Research (ISNAR) and the International Food Policy Research Institute (IFPRI) had to be treated separately as they do not have crop mandates. Although ISNAR is involved in research and extension methodology (including IPM evaluation) and in this way contributes to the methodology of IPM organization and implementation. IFPRI is concerned with the wider area of food policy and in this capacity influences the policy setting in which crop-protection decision-making takes place. In addition, IFPRI organized the first Centres private-sector exchange activity, which resulted in a publication highly relevant for IPM (Yudelmann *et al.* 1998). The material provided by ISNAR and IFPRI was used mostly in the concluding section of this study. Other Centres where (crop) IPM is not a major concern (e.g. the International Centre for Living Aquatic Resources Management – ICLARM and the International Livestock Research Institute – ILRI) were included whenever appropriate. Among the many publications that were listed or made available by the Centres only those cited in this report are included in the bibliography. Literature listed by Centres is included in the relevant tables.

3 Descriptive analysis of the Centres' IPM

This section presents the results of the questionnaire sent to the Centres via Email. In interpreting these results it is recognized that individuals rather than a group of people have replied. Mostly these were scientists who formally or informally chair the IPM activities and can probably be called the 'champions of IPM' at their respective Centre. In many cases they were researchers in the field of entomology.

The history of IPM in the Centres

The Centres were asked in what year they first labelled an activity as IPM. As shown in Table 2 this is generally identical with the emergence of the IPM concept in crop-protection science and mostly dates back close to the year when the Centre was established. There are some differences with Centres that are not commodity or crop focused (e.g. the International Plant Genetics Resource Institute – IPGRI, ILRI, ISNAR). For example, ISNAR has only recently started to become involved in IPM research in the context of a study on institutions and participatory concepts in natural resource management. The same is true for IFPRI (which did not participate in the survey) which together with the World Wildlife Fund organized a workshop on "Pest Management, Food Security and the Environment" in 1995.

Centres' interpretation of what they label as an IPM activity varies greatly and is a reflection of the many definitions of IPM that exist around the world. For example, in the late 1970s, the Asian Vegetable Research and Development Centre (AVRDC) did not use the term IPM but referred to 'judicious pest management'. In most cases the onset of IPM was equated with the implementation of an activity of one of the components of IPM, e.g. resistance breeding or biological control. However, in general resistance breeding was introduced before IPM activities were launched (Table 3). In fact, resistance breeding for Centres' mandate crops was usually a component of Centres' work from the outset, although its priority may have been low initially.

Based on the Centres' definition of IPM in most cases their first IPM programme was launched in the same year that IPM was first mentioned and IPM activities have been carried out for the majority of mandate crops. On a crop basis, at least four Centres have implemented IPM activities for rice (Table 4). For some crops, e.g. barley, chickpea and pigeon pea, IPM activities started later despite earlier work on resistance breeding. This divergence may be caused by Centres' interpretation of IPM.

Although Centres could have been asked for their definition of IPM this was not done because in the absence of a definition universally accepted by all stakeholders, this would have complicated the comparison. Therefore, in accordance with the definition given, all activities that provide alternatives to chemical pesticides and that contribute to move pesticide use towards their socially optimal level were included. Note that most IPM activities mentioned by the Centres were crop-specific with the exception of the International Centre for Research in Agroforestry (ICRAF). As a non-commodity Centre, ICRAF has implemented activities with a crop focus (e.g. *Leucaena* ssp) or with a pest focus (*Striga*).[2]

It is interesting to note from Table 4 that even for the same crop there is sometimes a considerable gap between when individual Centres first implemented an IPM activity. For broad beans *(Vicia faba)* for example, the Centro Internacional de Agricultura Tropical (CIAT) implemented IPM in 1982 while ICARDA only implemented it in 1994. Similarly, the International Rice Research Institute (IRRI) carried out its first IPM activity for rice in 1964 (although this was not field implementation) while CIAT did this some 14 years later. Of course, this is again a problem of IPM definition but it nevertheless shows the difference in the level of awareness and attention given to IPM by a Centre for a particular crop.

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2 The word pest is used for diseases, insects, weeds and nematodes.

Centres were also asked to list specific IPM programmes which they consider to be successful by their own standards; no evidence of success was asked for at this stage. The purpose of this question was to obtain an overview of the type of programmes that achieved some degree of attention. A question on programmes that failed was not asked because this would have forced the respondent to make a probably controversial judgement. (It is easier to ask people for success rather than shortcomings). However, these questions will be addressed in the later part of the report. At this stage of the survey simple descriptive parameters were used for background information to facilitate the definition of impact indicators later on.

It is interesting to note from Table 5 that there is a wide range of specifications given for these programmes. These include the control of specific pests such as in the programme on management of the common potato tuber moth in northern Africa (the Centro Internacional de la Papa - CIP), integrated management of all pests in a crop (IRRI), integrated crop management for rice (CIAT) and capacity building through fellowships (International Centre of Insect Physiology and Ecology - ICIPE). About half of the programmes listed in Table 5 belong to the category of individual pest control, while only a minority is attributable to capacity building or IPM methodology in the broader sense. This indicates that overwhelmingly IPM is still seen as a technical/biological issue rather than a management problem in the context of social science. In fact, only two Centres (IRRI and ISNAR) explicitly mention the social science dimension of IPM in specific programmes.

Again this is not a judgement on the quality of these programmes. However, it portrays the disciplinary orientation and the understanding that most Centres seem to have about IPM. The listing of 'successful' IPM programmes suggests that in many cases the perception about what IPM is, is closer to a technological paradigm rather than the social science process underlying the IPM definition given by Waage (Kenmore 1996):

"True IPM would be driven by local processes where many of these technologies may work partially, and solutions may require other components as well."

The recent work of ISNAR on developing and refining a framework for participatory intervention in natural resource management by small farmers and specifically for evaluating the farmer field school approach (Kenmore, 1995, Loevinsohn *et al.* 1998) indicates some change in this perception. Similarly, the IFPRI and the Worldwide Fund for Nature (WWF) workshop (Yudelman *et al.* 1998), where pest management was put into the perspective of food production and environment, may be another indicator of change. However, in both cases it is remarkable that only minor reference is made to the IPM activities of the Centres. In the case of ISNAR (Loevinsohn *et al.* 1998) the evolutionary framework was tested in an IPM programme which has not been implemented by any of the Centres nor probably with NARES.

At the IFPRI workshop only two of the 26 participants represented Centres and neither of these were actually involved in implementing IPM in the field at the time.[3] None of the 13 papers presented deal specifically with the role of Centres in IPM[4] although mention was made in the workshop conclusions to the CGIAR's role in IPM and to the Centres' IPM activities in the major ecoregions and/or commodities. In 1996, the System-wide Programme on Integrated Management (SP-IPM) officially began its work, yet no mention was made of the IFPRI workshop in the first Annual Report of the SP-IPM (IITA 1998). This apparent gap in inter-Centre exchange indicates some of the difficulties that the CGIAR System as a whole seems to have in conceptualizing IPM as a Centre-wide strategy and integrating it into its overall development objectives.

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[3] The two participants were Hans Herren Director General of ICIPE (associated Centre only), and Prabhu Pingali who at the time of the workshop was an economist at IRRI.

[4] An exception may be the paper presented by Hans Herren, however, this concentrated on the needs of Africa in pest management.

The integration of IPM in the Centres' activities

The integration into the Centres' overall goals and activities is believed to be a major pre-condition for the sustainability, and hence for the success, of IPM within the system. To assess the integration of IPM as a concept into the Centres' general research and development activities three questions were asked in the survey (see Appendix 1). The factors looked at were:

- evidence of integration in the form of relevant documents, mission statements or guidelines;
- the share of the core budget given to IPM;
- the organizations in the different countries, in the private and the public sector, with which Centres collaborate.

Table 7 summarizes the evidence given for the integration of IPM. This falls broadly into four categories: (1) outreach activities; (2) 'concept is implicit'; (3) general statements without reference made to concrete evidence; and (4) no integration of IPM. Note that the categories do not necessarily refer to any difference in the actual degree of IPM integration but illustrate the Centres' (respondents) definition of evidence.

In the first category at least four Centres can be listed: AVRDC, CIP, IRRI and the West Africa Rice Development Association (WARDA). IRRI's statement deserves special mention as they also refer to some documented evidence of IPM integration. Category two roughly applies to CIAT, the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), ICRAF and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) while the third category can be applied to the International Centre for Agricultural Research in the Dry Areas (ICARDA), ICIPE, IITA and ILRI. The last category covers ICLARM and ISNAR (also IFPRI which did not participate in the survey). For these Centres an integration of IPM cannot be expected because their purpose is different. However, the interpretation of IPM given by ILRI, and to some extent ICLARM, is remarkable in that they use a systems approach and interpret IPM more in a conceptual than a technical way.

Looking at the relative share of IPM in the Centres' current budget allocations (Table 8) the major difference stems from the inclusion of resistance breeding. Naturally those Centres not engaged in breeding have a lower share. However, among the crop commodity Centres (e.g. IRRI, CIAT, CIMMYT) there is considerable variation. This may be due to the difference in priority given to the various objectives in crop breeding relative to perceived constraints. It should be mentioned that many of the respondents pointed out that their figures are rough but nevertheless reasonable estimates and include estimates for operations and staffing.

Comparing the current budget estimates with previous allocations (before 1995 in some cases) shows that there has been an increase in the share devoted to IPM. Although for the unrestricted core budget there does not appear to be a clear shift towards significantly more investment in IPM. This may be explained by two factors: (1) increasing donor interest in IPM may have allowed the Centres to draw more from special projects; and, (2) the strong field-orientation of IPM, with its emphasis on training and providing expertise to other organizations involved in field implementation of IPM, may make investment from the core budget less attractive. The hypothesis that because of its interdisciplinary nature research related to IPM is less likely to result in publication in high-quality scientific publications needs to be investigated further. This will be done in a later section of the study.

A glance at the extensive lists of the NARES partners in IPM (Table 9) shows that some Centres operate worldwide while others are more region-specific. Overwhelmingly, partners are subsidiaries of national agricultural ministries in the form of departments or research institutes. In some cases, contacts are also with extension departments but those with research are dominant.

Collaboration with NGOs (Table 10) was mentioned by 11 of the 15 Centres answering the questionnaire. Only ICRAF, ILRI and WARDA did not mention joint activities with NGOs. There is a tendency for collaboration with NGOs to be most frequent for Centres operating in Latin America and least frequent for Centres operating in Africa, while Centres operating in Asia lie somewhere in between the two. Overall CARE, with its regional branches, seems to be the most important NGO partner. The most common collaboration is on IPM implementation projects, either through pilot schemes or in large-scale diffusion projects, e.g. ICRISAT through an IFAD-funded project. In some cases Centres participate in the transfer of components of IPM technology, for example CIAT together with CARE in some African countries. Training of NGO staff was also mentioned by AVRDC. Collaboration also occurs in NGO-managed agricultural projects where IPM is a component. Finally, there are projects where Centres collaborate with NGOs in research-type activities. Examples are IRRI's field study projects with national NGOs in Bangladesh and Thailand, and ISNAR's collaboration with NGOs in evaluating organic farming in Kenya.

Collaboration with the private sector in IPM was mentioned by nine of the 15 Centres (Table 11). In most cases collaboration is with agrochemical companies, quite often in the area of genetic modification for herbicide or pest resistance. The single company most frequently mentioned as a collaborator is NORVARTIS. Collaboration also takes place with national companies in developing biopesticides, e.g. CIAT in Columbia. It is remarkable that only one Centre mentioned collaboration with private-sector companies that are not input suppliers. ICIPE reported collaborating with the 'Exporters Association' for flowers and vegetables.

The future of IPM at the Centres

To complete the picture on the status of IPM at the Centres, respondents were asked to assess the relative importance of IPM during the next five years in the Centres' R&D portfolio. Respondents were given three categories, namely (1) stay the same; (2) increase; and (3) decrease. They were also asked for further comments. Results, including excerpts from the comments, are given in Table 12.

None of the Centres expects the importance of IPM to decrease and the majority (10 out of 15) expect it to become more important. The replies seem to indicate that: IPM has already reached a high level of importance relative to the Centres' objectives; IPM is not a central issue; or that there are doubts as to whether in a situation of tight funding the share of IPM can be increased. In most cases funding for IPM was mainly given to special projects and did not come from core funding. This is probably attributable to the nature of IPM activities, which have more of an outreach character. The comments of Centres who expected IPM to grow in importance were only moderately optimistic. Doubts were expressed with regard to funding and it is clear that there is little expectation of more internal funding for IPM. This in itself may be an indicator that in general IPM is not regarded too highly by the management of the Centres. Based on the opinions expressed, it appears that IPM will remain donor driven.

Respondents were also asked how they judge the future development of IPM in relation to the different IPM products outlined in the conceptual framework, i.e. in R&D, training, field implementation and policy work. The interpretation of the different types of IPM activities and the comments given once more portray the Centres' approach to, and understanding of, IPM.

The response to the question on agricultural policy aspects related to IPM was surprising. With a few exceptions, most Centres do not see a role at all. ICRISAT's comment was that there should be "lesser emphasis on policy" (see Table 12), IITA expressed interest and ISNAR and IRRI had a clearer view of what their role in IPM policy could be. A need was expressed for improving dialogue and establishing links between research and policy. Among the Centres that commented on the policy demand, AVRDC expressed the view that policy work is basically "information through educational material". The responses regarding IPM policy underline the dominance of the technical paradigm of IPM at the Centres. Clearly the relationship between IPM and agricultural and environmental policy, in particular the incentive systems as well as the relative advantage of IPM as a major factor in adoption, is not widely recognized. It appears as if the insights of economic research have still not penetrated sufficiently into the IPM community at the Centres nor, most probably, to their NARES partners. ILRI's viewpoint is interesting and is contrary to those of the other crop-mandated Centres. Faced with the consequences of structural adjustment in the animal-health sector in Africa, they expressed the need to better understand the relationship between liberalized markets and the delivery of animal-disease control technologies.

With regard to the emphasis on field implementation, most Centres see the need to increase their efforts either through on-farm testing in pilot projects or through training. Mostly they seem to rely on the traditional method of participating through NARS. In only a few cases was the need for the participatory approach mentioned.

Although most Centres did not specifically mention becoming involved in training farmers, some did. New ideas were expressed such as "less emphasis on short-term training and more on broader capacity building" (IITA) or training in "ethno-science" (IRRI) in order to improve researchers' communication skills.

Concerning R&D the comments were generally rather vague but portrayed a high diversity of viewpoints. Applied and adaptive research was mentioned as well as strategic and basic research. The two latter terms were mostly associated with transgenics and biological control. None of the Centres, for example, mentioned explicitly that research would focus on developing alternatives to chemical pesticides. In only one case (CIMMYT) was a clear focus given to biotechnology as the major technological component in future IPM. The high diversity of viewpoints with regard to the type of research needed for IPM could (a) reflect the different needs for IPM in different crops and different regions; (b) indicate that there is no well-formulated research strategy; or (c) show the degree of confusion with the IPM concept. In this connection, it is interesting to note that host-plant resistance was only rarely mentioned.

The future approach to IPM as seen by the Centres can be concluded from Table 13. Respondents were asked whether they envisaged changes in partnerships, and if so of what kind, for implementing modern IPM in the future. Remarkably, seven of the 15 Centres did not see a need for change as they seem to assume that what they are doing now is correct and will meet the challenges of the future. However, others do see a need for change.

For research the nature of partnerships is seen to shift to more collaboration with the private sector and high-level research organizations in industrialized countries. In a few cases the role of NARS is seen to be growing in importance (IITA, AVRDC) although it is not clear whether this is an actual expectation of what is going to happen in future or whether it is more an 'expression of hope'.

With regard to implementing IPM, it is worth pointing out that three Centres only mention NGOs. Of these, one mentioned collaboration with the private sector in implementing biotechnology and CIAT mentioned farmer/processor groups. This is interesting as it includes forward links with the marketing of produce rather than backward links with the input-supply sector. The question can be asked at this stage as to why the Centres do not recognize IPM more as a 'pull' technology and still rely on the 'push' factors in IPM. This observation fits in with the reluctance expressed by Centres to become engaged in working on a policy environment to help improve the conditions for a more rapid diffusion of IPM.

Summary and preliminary conclusions

This summary of the results of the survey undertaken with the Centres allows some preliminary conclusions. Although it is clear that care must be taken not to make too far-reaching conclusions from this descriptive analysis. Again it must be pointed out that the questions were asked by mail and there was little possibility to clarify unclear statements or questions. There are two factors which should be borne in mind: (1) how the question has been interpreted by the respondent and (2) the assessment is the respondent's view on IPM, although as the respondents were the 'champions of IPM' at their respective Centres the likelihood that questions were completely misunderstood is rather small. However, even taking into consideration the above factors, it is believed that some valid conclusions can be derived from the diversity of the replies.

With regard to the first part of the questionnaire dealing with the history of IPM, there are two observations that seem to be important. First, it can be said that IPM in most cases is almost as old as the Centres themselves. There seems to have been an early awareness of the danger of relying too much on chemical pesticides as the only means of pest control.

This is reflected in the high priority given to resistance breeding although initially this was not formally treated as a component of IPM. Secondly, and although the question was not specifically asked, understanding as to the meaning of IPM differs between Centres. Clearly dominant among the Centres is the technological paradigm of IPM, the technology transfer model. In some cases, however, this paradigm seems to be changing as a number of Centres at least mentioned the participatory concept in IPM implementation, as well as in the development of component technology.

For the second part of the questionnaire, that dealing with the integration of IPM in the Centres' activities, the most striking result is that little funding for IPM seems to come from the core budget. Probably because of its outreach character, IPM is largely a donor-driven programme. The replies of the respondents do not provide strong evidence that IPM has become the overall research philosophy. Yet there are some exceptions to this among the Centres that do not have crop mandates.

Replies to the third part of the questionnaire dealing with the future of IPM, strongly suggest that the dominance of the technological paradigm is likely to continue. Much hope seems to lie in the possible potential of biotechnology as the novel approach to IPM, although little was said as to what its actual contribution could be, whether reducing pesticide use or reducing losses. The responses show that an overall IPM strategy does not exist. For example, no mention was made of helping NARS partners design national crop protection plans although emphasis is placed on joint participation in IPM pilot projects and training. Neither do the replies to the questionnaires lend support to the assumed role of the Centres in providing alternative technologies to counter the efforts of the private sector to increase sales of pesticides and genetically modified crops. Rather this seems to be treated as a complementary activity. This view is also reflected in the question as to future partners as few Centres foresee a change in the type of partners. Overwhelmingly, IPM is still relying heavily on 'backward linkages' with the input supply industry. Only one Centre mentioned 'forward linkages', i.e. cooperation with marketing IPM.

4 Assessment of IPM research based on IPM publications

Only Centres directly involved with implementing IPM were included in this analysis together with ICIPE because of its cropping systems and insect ecology orientation. Centres were asked to provide lists of the publications that in their opinion relate to IPM. No subjective judgement was made as to whether the publication qualified for IPM as per the definition given at the beginning of this report. As already outlined the reason for analyzing publications was to identify evidence of impact in the scientific community. Publications were classified as being journal articles (national and international), book chapters or 'others'; others include newsletters, PhD theses, proceedings, conference papers and monographs etc.

Publication overview

Naturally the total number of publications differed widely among the Centres depending on their interpretation of IPM and as to whether records were available from the time when IPM had become a theme at the Centre. However, comparing the categories of publications indicates quality differences if it is assumed that quality requirements are generally highest for journal articles. Table 15 shows the publications listed by Centres. It can be seen that the proportion of journal articles is rather high indicating that most IPM research results are undergoing scientific scrutiny. Despite the, in principle, interdisciplinary nature of IPM, publications on IPM do not seem to be different from those on other scientific research. This could indicate that research on IPM is a component of research in the broader area of pest management and not necessarily labelled as IPM.

Table 16 supports this hypothesis. Screening of publications was done by searching for specific key words belonging to a topic related to IPM. The categories and corresponding key words used are given in Box 1.

It is interesting to note that based on the titles of publications, component research dominated as shown by the frequent mention of keywords in titles related to topics such as 'chemical', 'biological and cultural control', and 'resistance breeding'. On the other hand, publications, which are of a broader category or those that indicate some relation to other disciplines are rare. For example 'crop loss', an essential prerequisite for conducting problem-oriented IPM research, does not show up very often. Keywords under the categories of 'economics' and 'ecology', that would indicate some 'message' reaching beyond crop production/crop protection/agriculture, are found even less frequently. It is particularly these categories that apparently do not yet receive high recognition as being part of IPM.

Table 17 shows the result of a search for just one specific keyword in titles. These keywords were defined as belonging to the broader areas of the technological paradigm in IPM. Words that would show a clear link to the field of ecology such as 'environment', 'ecological sustainability' or 'biodiversity' are seldom found. This is even more so with words like 'society' or 'economy' that would show a connection with social science. The words 'food production', which could show a link between IPM and the broader food security debate, are rarely found. Finally the word 'farmer' occurs in less than 1% of the publications listed by Centres. These results by no means give any indication of the scientific quality of the publications listed by Centres but they do suggest where the priorities are once more show the technical perspective of IPM that seems to be prevalent at the Centres. To put it the other way round, strong evidence for the recognition of a social science dimension to IPM cannot be demonstrated.

Certainly one has to be careful with interpretations of this kind, which are based on sparse data with different possibilities of interpretation and on the perception of respondents. For example, CIP only mentioned the 16 publications labelled as IPM plus one book on economic impact that included IPM, while IRRI included everything that is somehow related to IPM. The analysis certainly suffers from possible communication gaps that may have occurred between the analyst and the respondents. There is also no doubt that the title of publications is an insufficient proxy for the actual content of the paper. The publication abstracts, together with keywords, would have allowed a more meaningful analysis. However, the time available did not permit a more intensive dialogue with the Centres.

Box 1. Categories and Key Words used In Publication Survey

Chemical Control: chemical control, control, insecticide, fungicide, herbicide, application, pesticide
Biological Control: biological control, release, parasitism, mortality, survival, sex ratio, mass rearing, mass production, predator(s), parasite(s), parasitoid, natural enemies, prey, phytophagous, neem
Cultural Control: cultural control, cultural management, effect of nitrogen, nutrient supply, plant reaction, plant density, seeding rate, time of planting, time of seeding, soil preparation, crop management, cropping system, cultural management, harvesting practice, tillage, field preparation, water management, weed management, deployment
Crop loss: crop loss, yield loss, severity, damage, yield reduction, yield formation, yield factors, yield, production, damage coefficient, injury
Diagnostics: evidence of disease, insects, weeds, occurrence of fungus, disease, virus, insects, weeds, population density, detection of, disease progress, pest outbreak, sampling, monitoring, population models, forecasting, pheromone, survey
Resistance Breeding: varietal resistance, selection, resistance to, resistant strains, breeding
IPM general: IPM, Integrated Control, Integrated Management
Ecology: food webs, biodiversity, ecosystems, ecology, ecological, environment, environmental, natural resources, nature
Economics/sociology: economics, economic threshold, benefit, profit, net return, net revenue, income, costs, perceptions, farmer behaviour, communication, social science, social nets, subsidies, policy, society, human health, externalities

That being said, this problem would only be serious if the purpose of this analysis was an 'Inter-Centre IPM comparison', but as the introduction makes clear, this is not the case. It is believed that the analysis does show that the image created by the IPM papers is low. Overall, the titles are not likely to attract professional, let alone public interest beyond the group of 'pest, pesticide and spider people'. This may have some relevance for the general status that IPM receives within the CGIAR.

Patterns of IPM development

By looking at the evolution of publications over time it may be possible to identify patterns of IPM development. These can show how research on IPM has been changing and what priority areas are emerging. Due to the huge amount of data it was not possible to look at all Centres in order to identify the way that the priority given to major topics changes over time. Therefore, one Centre from each region was selected: IRRI for Asia, IITA for Africa and CIAT for Latin America.

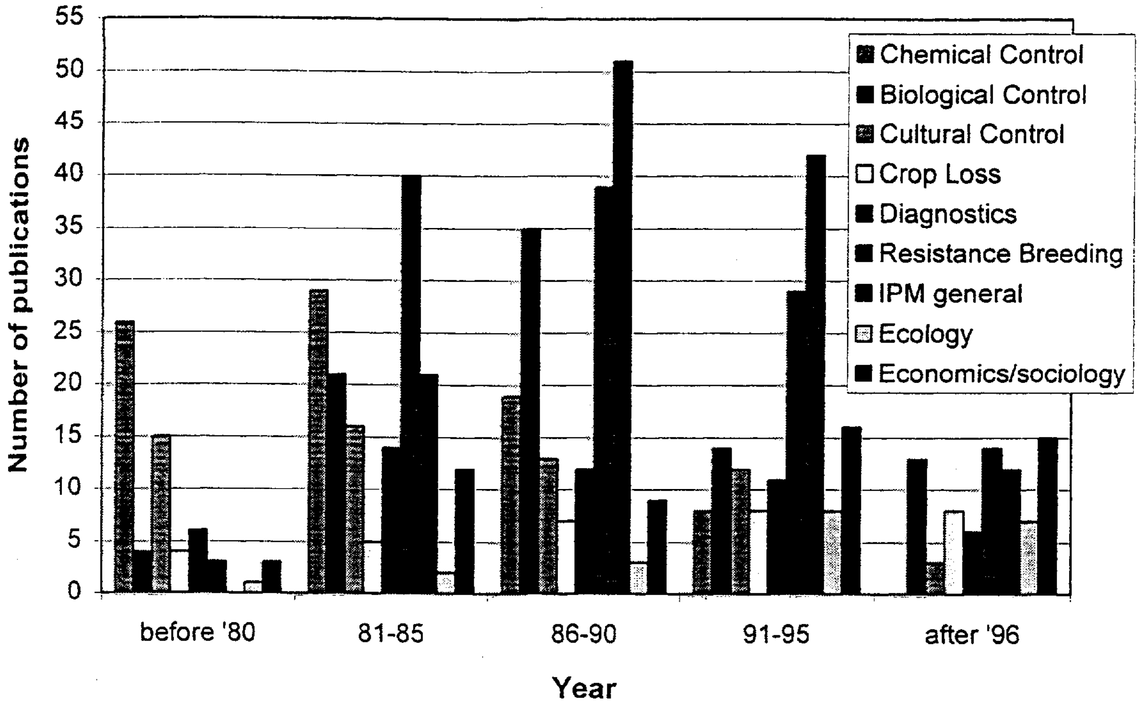

Figure 2. IRRI publications by category and time

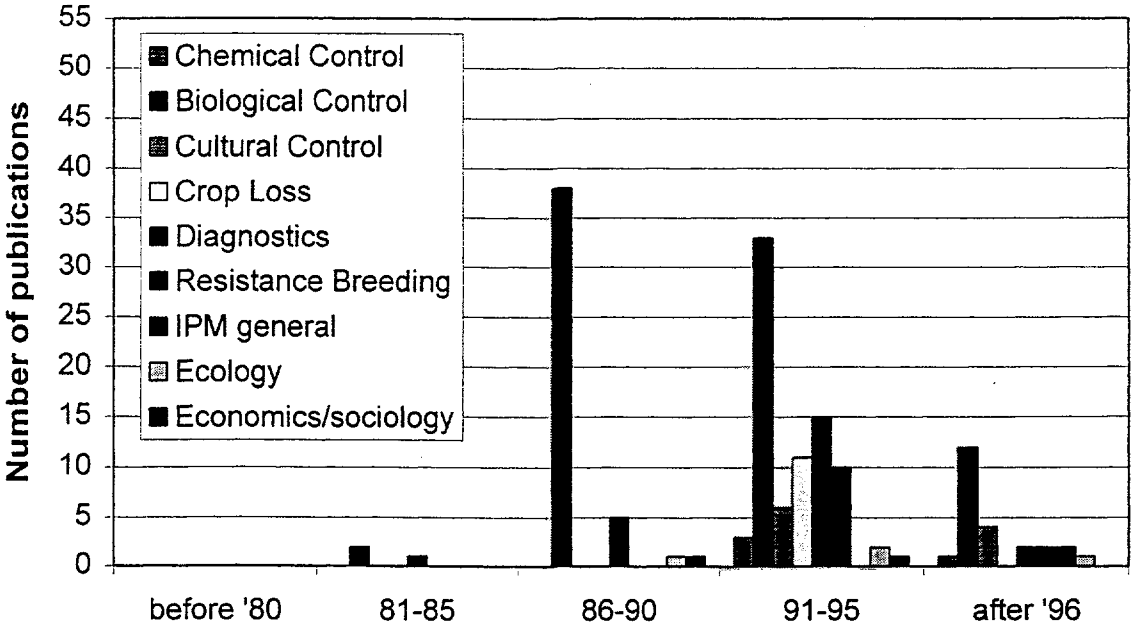

Figure 3 IITA publications by category and time

For IRRI it is possible to observe a 'path' in the frequency of publications under the categories used in Table 16. While prior to 1980 publications were dominated by the category of chemical control these disappeared after 1995. The peak of publications under the broad category of IPM was in the mid 1980s while the topic was non-existent prior to 1980. Resistance breeding, while hardly occurring in the 'early' period, has remained a high priority over time. The two categories that are shown to be increasing in importance over time are economics/social science and ecology. Some economic topics occurred from the beginning, while topics related to ecology, although they did not occur initially, are now on the increase. The analysis shows that with regard to rice in Asia, the decreasing importance of chemical pesticides is well reflected in the IRRI-IPM publications and an opening up to other disciplines becomes visible. With IITA a somewhat different pattern emerges. The clear dominance of biological control, also in the second half of the decade, is apparent. Some priority is given to crop loss and diagnostics but the analysis of keywords on 'ecology', 'sociology' and 'economics' seem to show that these are not an emerging issue in the IPM publication lists. This is surprising, as IITA has carried out highly reputable economic impact studies (e.g. Noorgaard 1988). Also notable is the low frequency of keywords on chemical control and general IPM topics.

For CIAT the pattern is again different. The number of publications with general IPM topics is rising and topics on biological control are clearly dominant. Also, the number of publications dealing with the topics of diagnostics/monitoring and resistance breeding has gone up during the second half of the decade. While some ecology-related topics are emerging this does not seem to be the case for sociology and economics. Publications with general IPM topics in the title remain few but contrary to the two other Centres, the number of publications related to IPM, as measured in the defined categories, have gone up rapidly in recent years.

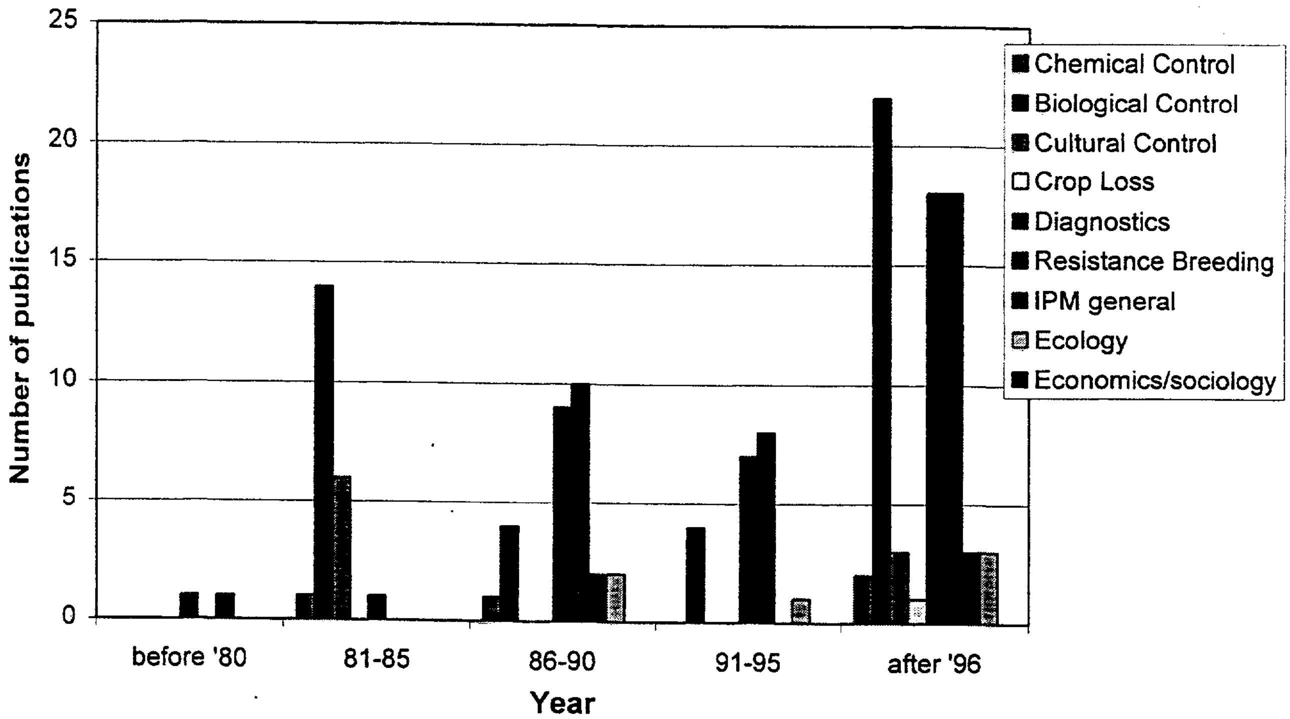

Figure 4 CIAT publications by category and time

On looking at all three Centres, probably the most striking result is that the topic of crop loss is not well reflected in IPM-related publications. This is surprising because the targeting of pest-management interventions is difficult to imagine without crop-loss information. In fact, detailed information on crop loss should not be restricted to percentage estimates on a pest-by-pest case but should include data on variability over time and across space. Most importantly, crop-loss studies should deal with the question of the causes for the changing patterns in crop loss. This kind of information would be of great value for the strategic planning of public-sector interventions and contribute to lowering the costs of food production and food security.

Relationship between journal impact factors and evidence of successful IPM programmes

The questions to be asked with regard to scientific publications on IPM is what is their impact on the scientific community and does this bear any relationship to the IPM programmes which the Centres rate as successful in the questionnaire. In other words does the success of IPM in the field depend upon scientific recognition of achievements? This was investigated by looking at the work of CIAT, IITA and AVRDC.

It seems clear from Tables 18, 19 and 20 that total impact points for journal articles as well as the number of publications related to a field programme do not suggest any such relationship. CIAT obtained the highest impact points for an integrated crop-management programme in rice while an IPM programme to control cassava horn worm and to breed cassava for resistance to bean viruses was published in fewer publications and had fewer total impact points. This example also shows the variation in the level of impact that is given by overwhelmingly relying on publication in internal documents. There does seem to be some relationship between the quality of impact study and the total journal impact points.

The situation for IITA was found to be somewhat different. IITA's most successful programme, the biological control of the cassava mealy bug, scored high impact points from journal publications. Almost 20% of all IITA journal publications can be attributed to this programme. Whereas another successful programme to breed resistance against maize streak virus for which no impact studies had been done, had a very low score. Another successful programme mentioned by the Centre, resistance breeding against African cassava mosaic virus had a moderate score. As evidence for this the IAEG impact assessment (Cooksy 1997) was mentioned.

An interesting case is that of AVRDC's project concerning the diamond back moth *Plutella xylostella*, probably the major pest of vegetable crops in Asia. The field release of the parasite *Diadegmma semiclausum* in the Philippine highlands is widely claimed as a success; however, no economic impact study of international standard has been published. The total journal impact score of 1,24 is rather low as is the percentage of journal articles in relation to conference publications. On the other hand, the less well-known project for Mung bean disease control in Pakistan had high impact scores and an economic evaluation, although this had not been published in an internationally refereed economic journal. The highest impact score was achieved by the programme for tomato disease control, a subject dealt with by a considerable proportion of all IPM publications of AVRDC. However, no specific mention is made of a formal (economic) impact study although a conference proceeding was mentioned.

Again it must be said that such analysis has procedural problems such as those mentioned in the previous section. Furthermore, the use of the journal-impact point index for evaluating research has been subjected to considerable criticism (Seglen 1997). Although this was originally developed for information management in science, the various types of citation indices are nevertheless being more and more used for research evaluation. The main criticism against its use for this purpose is that it assumes an ethics code among scientists, which in reality does not exist. Also, journal-impact factors are highly dependent on the subject matter. Usually, basic research where knowledge depreciates faster has higher impact points than applied science such as agriculture.

However, for the purpose of this analysis its use does have some purpose because comparisons take place within the same subject area. Furthermore, the comparison between journal impact points and perceived field programme success requires a quantitative indicator on the input site. The next best alternative would be to count publications without apportioning them any weight, which is preferable to using less than perfect weights. Keeping these shortcomings in mind, the conclusion can be drawn that only in exceptional cases does the amount and quality of science determine the success of IPM field programmes. The problem of course is that in the vast majority of the Centres' IPM programmes, success is 'perceived' rather than proven by rigorous quantitative analysis including economics.

Summary

The main issues are now summarized to highlight the findings of this certainly rather crude analysis carried out on the basis of the lists of publication made available by the Centres. From an overview of the publications lists the high proportion of journal articles is clearly a positive result. IPM publications are accepted in the scientific community.

Judging from the titles of publications it appears that the majority of these deal with component research rather than fundamental ecological or social science questions related to IPM. All in all, the titles may not be very 'attractive' to people outside IPM research or to clients such as extension workers who are charged with designing IPM field programmes.

Looking at the patterns of development of IPM as reflected in publications, three observations can be made:

- high frequency of biological control topics
- low frequency of chemical control
- low frequency of crop-loss studies.

Finally, there does not seem to be a relationship between 'publication success' and 'field success' for IPM. It was found that some programmes have high journal-impact points while others have low journal-impact points even though the Centres regard them as being equally successful.

5 The viewpoint of clients and partners

The purpose of conducting telephone interviews with clients and partners of the Centres was to complement the analysis presented in the previous section, which is to some extent based on a self-evaluation procedure. Therefore, unless the results are drawn from formal quantitative analysis they are influenced by the perceptions of the respondents. The viewpoints of 'others' regarding the Centres performance can be used to countercheck these perceptions.

Altogether 14 interviews were conducted with representatives of multilateral and bilateral development organizations (World Bank; the Global IPM Facility, FAO; CAB International-Bioscience, US-AID (and the Collaborative Research Support Program); GTZ; and DG XII of the European Union Commission), NGOs (CARE, World Resources Institute - WRI) and private companies (Norvartis, Zeneca and Monsanto). Organizations are considered to be clients if they use the Centres' IPM products and partners if they support the Centre directly or indirectly with resources. In reality, however, this distinction is less clear as the organizations mentioned can assume both roles.

The respondents were experts in IPM affairs (see Appendix 2) and could speak on behalf of their organizations although their views do not necessarily equate in all matters with the official policy of the organization. Prior to the interview the respondents were sent a questionnaire (see Appendix 3) by Email, which was then discussed during the telephone interview. Each interview lasted from 30 minutes to one hour and usually strictly followed the questionnaire. In the following summary whenever respondents are quoted (anonymously) this is in quotation marks.

Multilateral and bilateral organizations

The first questions dealt with contacts between the organizations included in the survey and the Centres. All organizations interviewed had contacts with more than one Centre. Overall, IITA was mentioned most frequently as a partner. The questions specified four main categories of collaboration: (1) information exchange; (2) the use of Centres' expertise; (3) contract research; and (4) collaborative projects. As shown by the interviews, the type of collaboration depends on the nature of the organization and no clear pattern can be identified. For example the Global IPM Facility at FAO carried out collaborative projects with WARDA and IRRI while the European Union, as a multilateral donor, only enters into collaboration with Centres through national partners. In the latter case, the particular concern is to form a "global front for IPM" through the establishment of better links between European IPM networks and the CGIAR System wide IPM Programme.

Respondents were also asked how multilateral and bilateral organizations rate the importance of the Centres relative to other partners in IPM. Here the answers were mixed. Some respondents mentioned the high quality of the Centres' "IPM products"; on the plus side they are also considered to be less academic than some universities. Others felt that national partners – because of their field contacts and knowledge of the local situation - are of higher importance unless national partners are particularly weak as in many African countries. One representative, however, was quite outspoken and stated that with regards to IPM "Centres are a factor but not a force".

When asked what was good and whether the Centres contribution to the respective organizations' IPM projects could be improved the answer was almost always "Yes, very satisfied but....." Among the 'buts' were high transactions costs "making a business contract with them is difficult and takes time because they are not service-oriented" and some lack of "field focus", "NARS" and "implementation" were mentioned. This viewpoint is underlined by a GTZ survey of the relationship between technical cooperation projects with the Centres

(Sommer 1996). However, this was not limited to IPM but included all areas of agricultural research. Furthermore concern was raised that in recent years the Centrs had suffered a "loss of pest-management specialists".

The second part of the discussion referred to the opinion of multilateral and bilateral organizations on the future of IPM at the Centres. Respondents were first asked where they see the future major role of the Centres and what type of IPM activity, i.e. methodology or field implementation, the Centres should concentrate upon. The answers were unanimous that the Centres' role was seen as being client-orientated "IPM knowledge Centres" demonstrating more openness towards other partners, especially NGOs. There was also agreement that Centres should concentrate on the methodology but that this should be more relevant for practical applicability: "The best way to come up with good methodologies is to do field projects in collaboration with especially NGOs but also NARES". Respondents also agreed that Centres should not carry out field implementation themselves but should continue to stay on the technology side and contribute to a better understanding of the social aspects affecting IPM implementation and adoption. However, the need to give higher priority to field implementation, in collaboration with other partners, was clearly expressed.

Regarding the Centres' investment in IPM and the level of attention given to this by the Centres management and their scientists, answers were more divergent. Some still considered pest problems to be the major constraint to food production and productivity, and therefore saw the need to allocate more resources to this. Others saw the danger of IPM just becoming another major catchword for attracting donor funds. It was not so much the relative budget share that was seen as the main point but establishing effective links with other disciplines, a reallocation of budget to priority areas and a stronger commitment towards "fundamental ecology". These were considered to be more crucial for effective IPM activities.

Among those who called for an increased budget for IPM, opinions differed as to whether this should go to more research on germplasm and biotechnology or to alternatives to biotechnology. This divergence of opinion is best demonstrated by the following two statements: "In research more money should be allocated to biotechnology" and "What can be done by the private sector should not be done by the public sector but even if there is a market for technology it is in the public interest to be aware of the direction in which the private sector is moving".

The last question was for the need for an Inter-Centre IPM strategy. Here the replies were more similar. The need for such a strategy was seen to be not only necessary but also advantageous: "donors could use this as a quality standard to make better funding decisions"; (b) "better marketing of results"; and (c) "easier for partners to collaborate".

The key questions underpinning the development of such a strategy were formulated by one respondent as follows:

- What is the Centres' comparative advantage?
- Who are the key partners?
- What is the way of collaboration?
- What shall be achieved?

It was mentioned that the System-wide IPM Programme is considered to a good start in this direction, although some concern was also raised that the diverging interests of the Centres could make this difficult to achieve.

NGOs

For the interviews with NGOs, two organizations were contacted: CARE and WRI. From CARE, two representatives were interviewed because of the difference in experience with Centre collaboration. Although it would have been useful to talk to more NGOs this was difficult because those collaborating with Centres are usually local and, therefore, difficult to contact. Also to look at the Centre-NGO relationships in an in-depth manner would require a separate study. That being said, the discussions which were held with the representative of these international NGOs are believed to reflect these types of clients.

The organizations included in this category collaborated with almost all the Centres that work in IPM although the type of collaboration varied among the organizations. CARE had joint field projects with CIP in Peru but overall rated collaborative work with individual Centre researchers as the more common form of collaboration. WRI's collaboration was often in the form of contract research through small grants for doing studies, such as that of IRRI on pesticides and health.

With regard to the importance of the information provided by Centres on IPM, CARE representatives rated the Centres as a major source, although this occurred more for Latin America than for Africa and Asia. WRI considers the Centres' IPM products as important but rates other NGOs as their more important partners.

WRI and CARE expressed satisfaction with collaboration with the Centres; CARE especially mentioned the CIP project "With no doubt we would do it again". However, the issue of transactions costs was also mentioned (see section 7): "It is a bit confusing and frustrating that the Centres still continue to do research in isolation and pull back researchers from extension". The same point was made by WRI.

With regard to the future role of the Centres, CARE believes that more effort is needed to build human capacity in IPM (trainers and other professionals). WRI suggested more engagement in partnerships and abandoning the artificial separation between 'upstream' and 'downstream'.

CARE and WRI agreed that there should be more investment in IPM but expressed concern as to the type of IPM. They do not want "more of the same" but suggest that Centres overcome the technological focus and include disciplines beyond "entomology" which was felt to still dominate IPM. To invest additional money in alternatives to biotechnology was another proposal for the possible use of additional IPM investment.

On the question of methodology versus field implementation, respondents still saw the need for research but using a different scheme. It was proposed that Centres should work together with others (FAO, NGOs) and develop methodologies that take the field situation into consideration. CARE would welcome the Centres providing more training in field implementation.

WRI and CARE welcome the issue of a System-wide IPM strategy as they believe that this will make the System's role in global IPM more transparent. However, CARE warns that this should not lead to making "everyone look alike, we need more diversity in science". To summarize, while all respondents with the exception of CAB expressed satisfaction in working with the Centres, the need for change was clearly voiced.

Agrochemical industry

Interviews with representatives from the chemical companies were carried out because of the pivotal role these play in influencing the path of technology development in pest management, national policy, the international rules that guide the inter-country flow of technology and farmer's pest control practices. One hypothesis is that companies are interested in the development of IPM by the Centres because research outputs are regarded as being non-rival and non-exclusive pest management technologies, which complement private plant-protection products. At the same time the Centres can assume the role of broker in helping national systems make appropriate selections from a 'basket' of technologies. Furthermore, as explained in section 4, private companies have embraced the IPM concept to market their plant-protection products although their definition and understanding of IPM is not necessarily identical with that of public-sector institutions.

The companies contacted were Zeneca, Monsanto and Norvartis. On the recommendation of the latter, the Norvartis Foundation for Sustainable Development (Dr Leisinger) was also included. In the interview with Zeneca, two respondents participated, one representing crop protection and the other seeds. The Monsanto representative was a former CGIAR scientist (Paul Teng). The company representatives were asked the same set of questions as the other groups except for that on the System-wide IPM strategy. No recommendation was expected on this, as such a move is not likely to be in their interest.

Only seven Centres were mentioned as collaborating with the private companies, the main ones being CIMMYT, ICRISAT and IRRI. The type of collaboration mentioned was mainly "information exchange" and "informal meetings", however, there was also more formal collaboration and contract research as well as the exchange of seeds.

In terms of the importance of the Centres as a source of information for the companies' IPM activities the answers can be rated as "moderately enthusiastic". Not surprisingly, the companies consider the NARES of greater importance than Centres with regard to their goals of implementing the "industry-defined IPM". Some respondents found it difficult to rate collaboration with Centres except for one who clearly stated "completely happy with CIMMYT and IFPRI, happy with ICRISAT and not happy with IRRI".

With regard to questions relating to the future of IPM at the Centres, company representatives expressed a range of opinions. The "broker and networking role" of the Centres was pointed out and some stated that having the Centres as brokers would make it easier for companies to share their "knowledge products" with different stakeholders. Centres were also considered to be potential partners of private companies in outsourcing companies' in-house research activities. On the other hand, doubt was raised as to whether the definition of IPM followed by many of the Centres, which they see as being influenced by developments in the industrialized countries, are really relevant to the mission and the goals of the CGIAR system, i.e. the alleviation of poverty and hunger.

Company representatives did not see much need for increasing funding for IPM and raising the level of attention given to it. They draw a relationship between the Centres' definition of IPM (as perceived by some companies) and more investment in IPM as the following two statements make clear:

- "More attention and more investment in IPM would be desirable provided they adopt a broad definition of IPM."
- "Centres should not invest more money in IPM but reallocate money to support research on IPM. They should not work on the implementation of technologies against certain pests in a particular area (this is the job of NARES). Rather they should do more research on IPM-related issues such as ecological, genetic, socioeconomic and policy aspects".

With regard to the question as to what aspect of IPM the Centres should prioritize it was clear that company representatives see the Centres role in a broad range of IPM-related methodological issues rather than in collaboration on IPM field implementation. Companies would like the Centres to be of more assistance in increasing the acceptance of new technologies in developing countries. Most of the additional comments emphasized the need for more dialogue and information exchange but no specific elaboration was made on what issues, other than poverty and hunger and funding agricultural research, should be discussed.

Summary

The interviews with representatives of these three groups of stakeholders in IPM show a considerable difference as to what is expected of Centres. Clearly, while the private sector wants the Centres to stay away from the field other sectors want them to become more field-orientated. While there is general satisfaction with the Centres' IPM-activities stakeholders do see a need for change. The following two aspects are important in relation to this:

- the need to integrate methodology and field work
- the need to formulate a System-wide IPM strategy.

6 Economic case studies

The purpose of this section is to review some selected case studies on the economics of IPM developed by the Centres and implemented either by the Centres in collaboration with the NARES or with other partners. Studies were selected on the basis of region and to reflect the range of IPM activities. Before presenting the cases a short reflection of past economic studies on agricultural R&D will be given. This review can serve as a reference in evaluating results of the IPM case studies.

A short review of the economics of agricultural R&D

Like any other investment in agricultural research, investments in IPM can be subjected to economic analysis. Generally R&D in agricultural technology has paid handsomely in both industrialized countries and in the developing world. For example, looking at studies that estimated the rate of return of agricultural R&D in the USA from 1958 to 1989, in only 10 out of 80 cases were the rates of return below 30% (Alston and Pardey 1996). In fact, the chance of a rate of return being below 10% is extremely low (Figure 5). By producing a cumulative frequency distribution of rates of return from the Appendix Tables in their report, it can be seen that there is unlikely to be any stochastic difference between such investments in developing countries as opposed to developed countries (Figure 6).

The hypothesis that the rate of return on investment in non-profit agricultural research is high in relation to that in most other alternative investment opportunities has dominated the literature for many years (Schultz 1971, Ruttan 1980). This has led to the 'Underinvestment in Agricultural Research Hypothesis' (Evenson *et al.* 1979). That being said, some substantial arguments have been raised against this hypothesis (e.g. Fox 1985), pointing out that considering the true social costs of public expenditure, investment in agricultural research may generate returns comparable to those in other sectors. Recently the above hypothesis has been subject to quite emotional debate. For a long time it has been assumed that based on the results of project case studies, e.g. in Kenya, the estimated rate of return is over 100% (Bindish and Evenson 1993). These results were challenged by a recent World Bank Study pointing out that the rate of return in this project could well be zero (World Bank 1999).

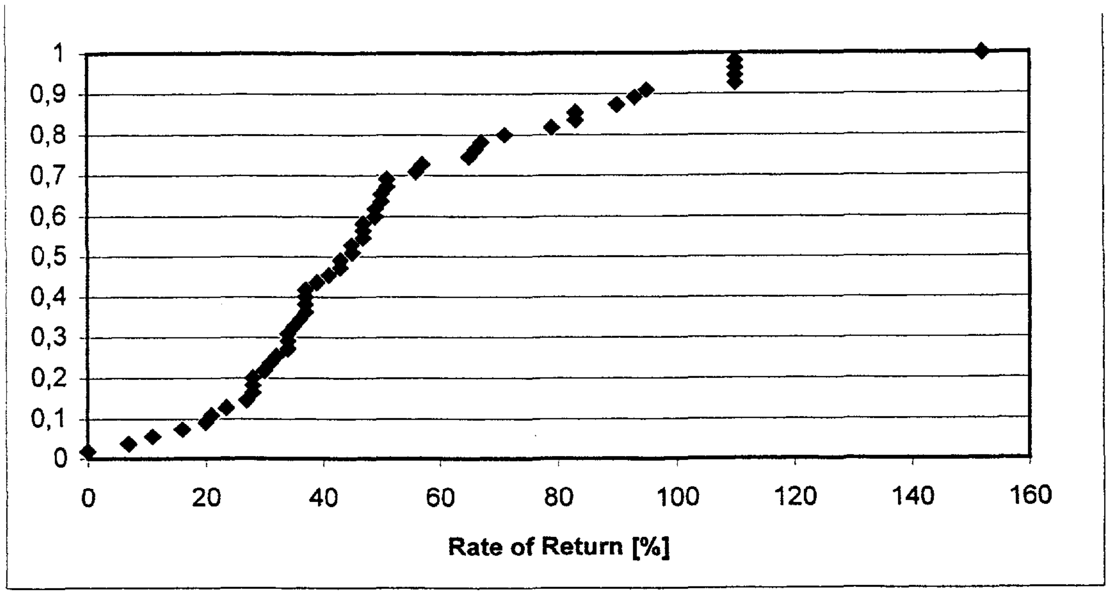

Figure 5 Cumulative distribution of estimated rates of return to US Agriculture R&D 1958-1989. Source: Alston and Pardey 1996

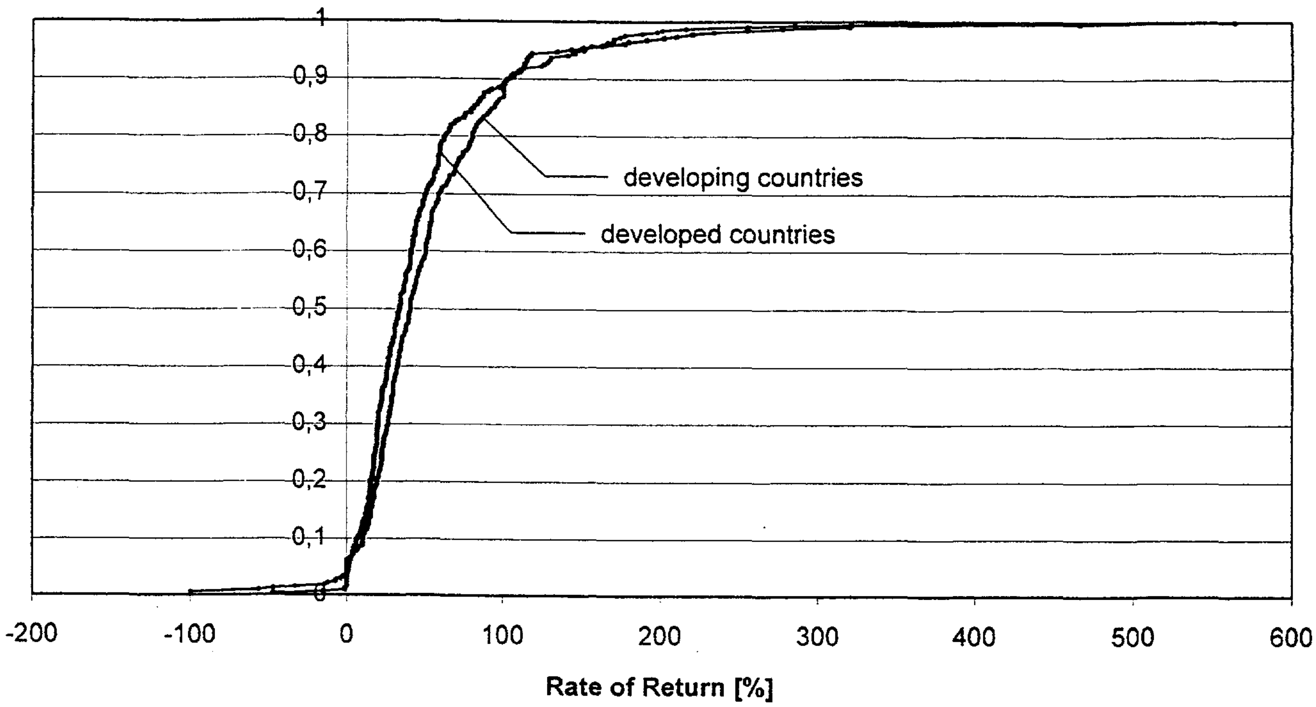

Figure 6 Cumulative distribution of IRRs of Agricultural R&D projects. Source: Alson *et al.*1998

It is important to recognize these recent discussions on cost-benefit analysis of agricultural research and extension when examining case studies of IPM in the context of this analysis. There are two important points to keep in mind. First, the question of what can reasonably be expected from investment in IPM, i.e. are there factors affecting IPM that make the rates of return different from those of other agricultural technologies? For example, the returns to improved pest management (in the spirit of IPM) depend on the pest situation and very often on human interference in the ecosystem in prior periods. If the ecological balance in a cropping system has been significantly disturbed, pests may become a major factor. In such cases research providing efficient control methods can yield extraordinarily high returns.

Secondly, an economic analysis of IPM almost always necessitates looking at the combined effects of research and extension. As shown by Traxler and Byerlee (1992), IPM can be subsumed under the category of crop-management research that emerged in the post green-revolution period. Typically this is public-sector research because its output is information for small-scale farmers. It also differs from the green-revolution technology whose main output has been yield-increasing modern varieties. IPM, in most cases, falls into this later period of technology because it is yield maintaining rather than yield increasing, and (external) input saving rather than (external) input increasing. In fact, what IPM does in many cases, is to substitute external inputs (pesticides) by information. This process can take place in a situation of drastic pesticide overuse but also during the course of sustainable intensification. It is clear that in disseminating IPM products extension is important because the value of information may depreciate over time and through transfer from farmer to farmer

Case studies on the Economics of IPM in the Centres

The three studies selected for highlighting in this analysis are:

- the biological control of cassava mealy bug in Africa
- the IPM practices on the Andean potato weevil in Peru
- the use of insecticides on Asian rice and farmers' health

These three cases differ substantially. The first is an example of classical biological control, the second is a rather typical IPM field project with a science-based extension of IPM technology components and the third is a rather atypical IPM activity as it is an example of a paradigm shift. While for the first two examples rates of returns have been calculated this has not been done for the third example. A short description of the case studies is given followed by interpretation and assessment.

The cassava mealy bug

Cassava (*Manihot esculenta*) was brought to Africa some 300 years ago from South America. The crop has probably changed the nutrient supply and consequently the diet of the people in Sub-Saharan Africa as much as the potato (*Solanum tuberosum*) did in Europe. Cassava has become a major staple for more than 160 million people in Africa. In the early 1970s a problem with two pests emerged: the cassava green mite and the cassava mealy bug. Both pests were introduced accidentally and illegally with planting material. Thus their introduction to Africa can be considered to be the result of institutional failure, ineffective quarantine services. Both pests did not have such 'status' in their area of origin because they co-evolved with their natural enemies, which kept them in check. In fact, the cassava mealy bug (*P. manihot*) was only 'discovered' in Paraguay in 1980 by A.C. Belotti from CIAT (Schaab 1997).

The cassava mealy bug spread quickly over most of the cassava belt in Africa reportedly causing significant economic loss (Walker *et al.*). Shortly after the pest had been found, its natural enemy, a parasitoid wasp (*E. lopezi*) was selected and reared by IITA. In 1981 the first release of the parasite took place and one year later it was distributed to the mealy-bug infested African countries. Since 1992, the mass rearing and release operations for *E. lopezi* were terminated. In most of Africa the pest is now controlled and it has lost its pest status as the ecological balance has been restored.

The return on this investment has been analysed in two economic studies (Noorgaard 1988; Schaab 1997). Both came to the same conclusion; even when using the most conservative assumptions the cost-benefit ratio is well over 100. This case is used to demonstrate that no other pest management technology can 'beat' such biological control investments (Herren 1999).

To interpret this obviously extremely successful example of public investment in pest management it is necessary to go back to the definition of IPM activities set out at the beginning of this report. This includes any activity of the Centres that can help to bring pesticide use closer to its social optimum. In the case of cassava in Africa, pesticide use (or even overuse) was not the issue at all. However, one has to look at the history to identify the case more clearly. The cassava mealy bug project dealt with an emergency. To illustrate this point more clearly the metaphor of the house on fire will be used.

Quick help was needed or else the house might have suffered further damage. The fire started because the quarantine service failed to prevent infected planting material coming into the country. So it is the quarantine service that put the house on fire although it is the job of the fire brigade to prevent such fires. If that is the case, should we not blame the quarantine service, i.e. add the costs of the quarantine service to the costs of the project combating the cassava mealy bug? This should only be done if these two damaging organisms had been placed on the hit list before. Obviously, they were not because in their home country they enjoyed a status of 'honourable citizens', not engaged in any activities damaging to society. Therefore the African quarantine officer was unaware of the danger and the fire started as an act of God. The people were given the choice to either suffer or find an answer to their God's question."

It is clear that once the cassava pest problem had become a 'public bad', a public good was needed to counter it. At that time biological control was probably the only feasible option. The question then is what would have happened if this public investment of the IARCs had not been undertaken? Would another solution have come from the private sector for example and could the cassava case have taken the path of desert locust control with widespread application of subsidised chemical inputs (Hardeweg, 1999)? Taking the locust experience, the social costs of such a decision would have been immense. Today, the alternative solution would be to insert some genes resistant to mealy bug into the cassava plant (Herren 1999) with uncertain benefits and largely unknown risks. Therefore, if this case is treated in an evolutionary framework the investment in classical biological control of the cassava mealy bug can be charácterized as an IPM project.

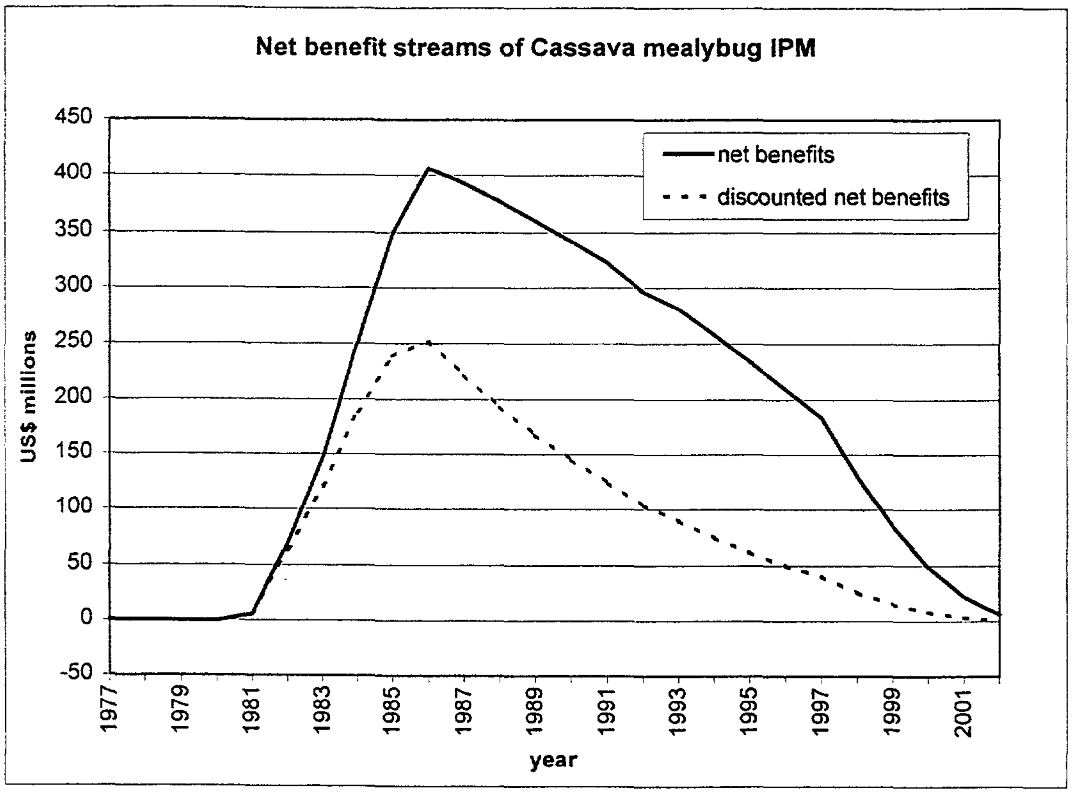

Figure 7 Net benefit streams of cassava mealybug IPM. Source: Noorgard 1988

This further underlines why the benefits of this project were so high. In the absence of realistic alternatives, the comparison was between control and no control. Such comparison usually gives significant differences if there really is a pest problem. There is overwhelming anecdotal evidence and expert judgement proving that this was the case. However, from a scientific point of view the case would have been even stronger if there were scientific crop-loss studies. Unfortunately, the only reference that was looked at in the Noorgaard study on crop loss due to both cassava pests was an unpublished and undated report by Walker *et al.*

The lesson that can be drawn from this study is that the return on investment in research to solve emergency pest problems, which are often created by prior misguided human interventions, is usually high. This is especially the case when solutions can be implemented as a non-rival good 'from the air', that is without bureaucratic entanglement such as credit programmes and without the need to convince the farmer. The question that remains is how to treat the costs of prior human interventions in this context.

IPM of the Andean potato weevil in Peru[5]

Together with the problem of late blight, the Andean potato weevil is a major cause of economic damage to potato production. To help farmers solve this pest problem, CIP together with a NARES partner in Peru, started an adaptive on-farm research project in two potato-growing communities in the Andes in 1991. This project was based on the research results of IPM practices developed by CIP.

The potato weevil is a pest whose biology is difficult for farmers to understand. Adult females lay their eggs at the base of the potato plant. On hatching the larvae move into the soil and feed on the forming tubers. After harvest the adult weevil can move from the potato store back to newly planted potato fields. As the pest is underground most of the time, detection and control is difficult for farmers.

Damage assessments conducted at the beginning of the project showed that farmers had to cope with an estimated damage level in the order of 30% to 50% depending on the location. Apart from damage caused by loss of weight in the potato the market also recognizes other levels of damage and reacts by discounting the price. For example, if more than half of the potatoes are damaged the corresponding loss in value is 67%. Interestingly, farmers do not recognize the weight loss, reportedly because they only weigh the undamaged production. Only when farmers process potatoes do they realize that more units of undamaged potatoes are needed to produce one unit of processed food.

The project introduced several IPM practices by means of communications and field demonstration techniques. These were comprised of measures including chemical control with selective insecticides, cultural control such as adjusting harvesting time, soil management, tillage after harvest, mechanical control such as covers for transport, ditches around potato fields as well as vegetative barriers, and elimination of volunteer plants. Additionally there were practices such as handpicking adult insects and using chickens to eat larvae. Biological control by means of the fungus *Beauveria* was also introduced.

Although not all the practices were adopted by farmers, a before-and-after study showed that farmers could substantially reduce damage and increase their net income on average by US$154 per ha. A cost-benefit (financial) analysis using the survey data collected in the locations showed an internal rate of return of 30% assuming that all research and development costs were included, and that the project had a service life of 20 years. The cost-benefit study was applied on an NGO (CARE) supported project with a target area of almost 4000 ha, about 2% of the total potato area of Peru. The analysis was based on rather conservative estimates on the cost site – judged to be lower in reality – and rather solid assumptions on the benefit site.

The case of the Andean potato weevil is a typical crop management, combined research and extension project, and as such it is a typical IPM activity. The farmer has to make a choice between different components and combine control tactics that best suit his/her objectives. Unlike the previous case, here the crucial variable is farmer adoption and success depends largely, therefore, on the effectiveness of the extension service. However, as in the previous case, results depend on the reference system used, i.e. what would have happened if the project had not started. In the above case the assumption was that for 20 years the situation would have remained unchanged if there had been no project. Such an assumption could be challenged if the possibility of indigenous technology development and self-help capacity is taken into consideration. Therefore, it is probably useful to subject the data published by Ortiz *et al.* (1996) to some sensitivity analysis in order to test how robust the result of the analysis on the rate of return is.

Figure 7 shows the undiscounted cumulative cashflow of the project under different assumptions. Computing the internal rate of return (IRR) for alternative scenarios shows that results are indeed very stable. For example, if the rather optimistic adoption curve for the IPM technology is somewhat flattened, i.e. the maximum adoption is only reached twelve years after the first investment in component research instead of after five years as assumed

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[5] This excerpt summarizes the article of Ortiz *et al.* in the book "Case studies of the Economic Impact of CIP-related technologies" edited by T.S. Walker and C.C. Crissman (1996)

in the study, the IRR is still 26%. Even reducing the per hectare benefits (see Figure 7) by 50% or cutting off the benefit stream 10 years after the first adoption (assuming that farmers would have found out by themselves in that time) would not drastically change the result. Only when making an assumption that 10 years after the start of the component research, i.e. six years after the first adoption, an indigenous solution would have emerged anyway, does the IRR drop to 6%. It is clear that changing these assumptions is purely speculative but it does make the case more transparent.

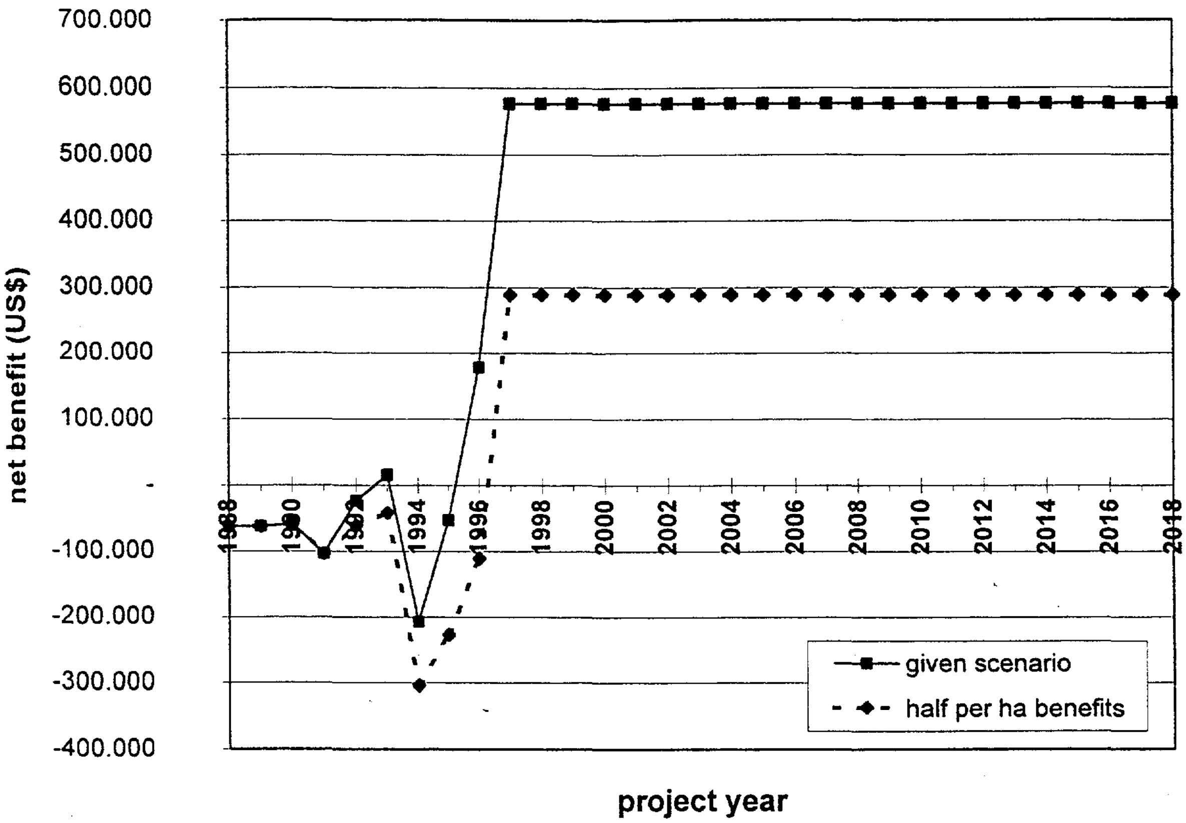

Figure 8 Net benefit stream of the CIP project on the Andean potato weevil. Source: Ortiz *et al.* 1996

It can be concluded from this case study that if IPM technology becomes rapidly adopted the rate of return on investment in research and extension pays off. However, a word of warning becomes necessary here. As in most cost-benefit studies on IPM, this study of CIP (which actually is a financial analysis only as no shadow prices were used) refers to a pilot scale. There are inherent dangers in scaling-up such projects. For example, the per hectare benefits may drop because the initial momentum of pilots can seldom be maintained when scaling up. Also, very often pilots are in areas where the potential benefits from IPM are high either because the area is a classic case of pesticide overuse and/or a locality where pest problems are rather severe. To some extent the CIP case study has taken this into account by including a 'lower potential community'.

The economics of insecticide use in Asian rice

Although a comprehensive cost-benefit analysis has not been conducted to date on IRRI's IPM activities for rice, the many studies that are available allow some conclusions to be drawn. Mainly because of the FAO Inter-country Programme, and the success it has shown in changing pesticide policy in Indonesia (Kenmore 1991), IPM for rice has become very popular. IRRI became involved in this development very early on (see Table 1) and it is reasonable to assume that it has significantly influenced the debate as to the most cost-effective approach to implementing IPM for rice production in Asia. Much of the science that underlies the popular farmer field school approach of FAO (Kenmore 1996) has been generated by IRRI, such as the fundamental research of Kenmore *et al.* (1984) and the widely recognized study on pesticides and farmers' health (Rola and Pingali 1993).

After several decades of IPM-related research the message concerning insecticides and rice is rather simple "in general don't use them". Rather than a solution to pest problems, insecticides for rice seem to be a major cause of pest outbreaks. This has led researchers to state that even in intensive rice production insecticides are "not needed" (Way and Heong 1994). Already in the early 1980s some doubts were raised on the economics of insecticide use in rice. For example, the study of Herdt *et al.* (1984) stated, "no reduction in economic risk is achieved by applying high levels of insecticides". Repetto (1989) using the same data as Herdt but adjusting pesticide prices to account for subsidies found that in most cases insecticide use does not pay off. Similar results were found from simulation studies in the Philippines (Waibel 1986) and in China (Widawsky 1996) and from empirical work in Thailand (Waibel and Engelhardt 1988).

Finally, the Rola and Pingali book (1993) "Pesticides, Rice Productivity and Farmer's Health" produced two important messages highly relevant for IPM in rice:

- in a 'normal' (pest) year insecticide use does not pay off for rice farmers, and
- if health costs are included insecticide use for rice is uneconomical.

Despite these clear messages and the growing body of evidence that insecticides are being misused in Asian rice production, not much seems to have changed in farmers' fields. Although success could be demonstrated in selected areas in Indonesia and Vietnam (Kenmore 1991, Pincus 1996) in the aggregate there is no evidence of a paradigm shift. Based on industry data on pesticide sales in Indonesia, Malaysia and Thailand, Oudejans (1999) found, at least in Thailand and Malaysia, that the pesticide markets remained unaffected by programmes on IPM.

According to these data, in Indonesia the effect was small because only a fraction of the total farm population was reached by IPM. In the Philippines, the host country of IRRI, insecticide use may be less in terms of active ingredients per hectare (Rola and Widawsky 1998). However, the evidence is not clear as becomes apparent from the study of Heong *et al.* (1997) and Rola (1999). Horstkotte-Wesseler (1999) reported that in the early 1990s the average frequency of pesticide application of three per cropping season is about the same as it was 10 years before (Waibel 1986).

Despite considerable investment in IPM implementation by other international organizations, there is a large debate over the most effective way to advance the adoption of IPM by Asian rice farmers. IRRI has become actively involved in this debate by challenging the farmer field school approach, which was successfully tested in Indonesia and Vietnam but criticised for being too slow and costly. Instead, IRRI has been pushing for a strategy that has become known as the "no spray during the first 40 days rule". The rationale for this strategy, which is less intensive in terms of human capital, is that most farmers unnecessarily still spray during the early stage of the rice crop, which may stimulate pest growth in later stages. The message has been relayed to farmers by using communications media. This approach has been tested in Vietnam and is claimed to be successful (Heong *et al.* 1998) but no formal economic analysis has been conducted. Overall, while success of IPM in rice has been demonstrated in selected areas, no conclusions can be drawn at the aggregate level as no study has yet been carried out.

The case of IPM for rice is a good example of the implementation of IPM with a solid scientific base. It is apparent that the investments made yielded the kind of outputs that were clear enough to be used by extension workers to empower farmers in pest management. Yet, 35 years after the first IPM activity at IRRI, no convincing evidence can be found for real changes in Asian farmers' rice fields outside the pilot areas. Therefore, nothing can be said on the rate of return of this investment.

However, it is clear that the potential benefits are tremendous. The 20% budget share for IPM at IRRI is probably in the order of US$5 million per year on average yet this is a small fraction of the potential benefits. Given the US$250 million that Asian rice farmers spend on insecticides every year and using the Rola/Pingali health cost factor of 1:1 (pesticide costs to health costs) the benefits of IPM for Asian rice could be up to US$500 million annually. Simulating the Benefit Cost Ratio (BCR) at a 10% discount rate, illustrates what timelag means. If 35 years have been spent on IPM research but the knowledge is not applied because of institutional and policy constraints, the BCR quickly approaches unity. Even when health benefits are considered "time may be running out".

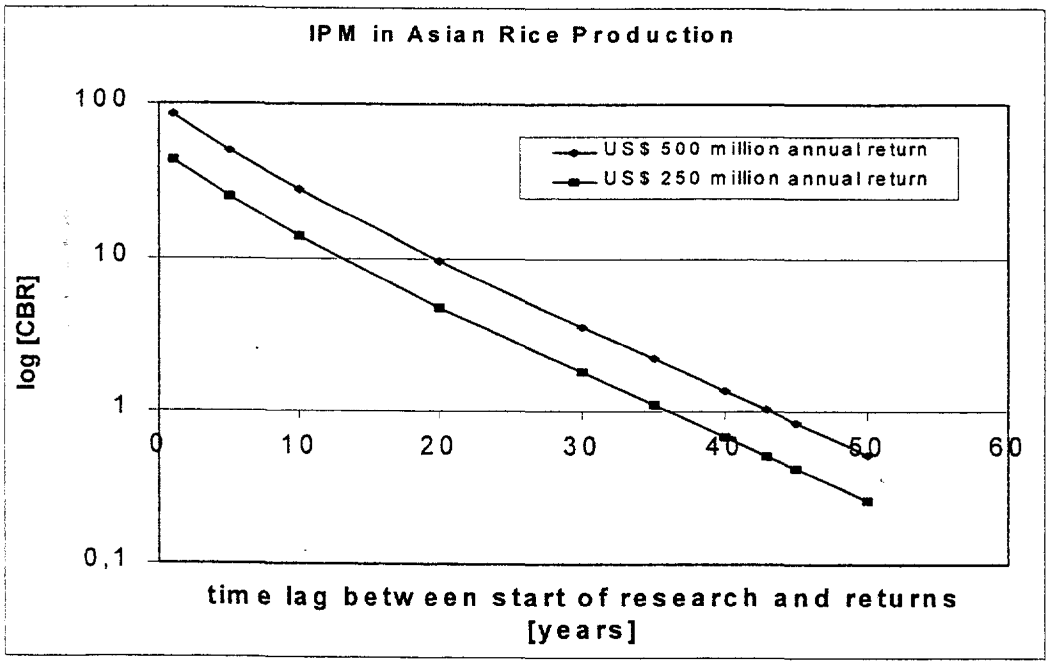

Figure 9 Benefit cost ratio of IPM research in Asian rice production

It is clear that such number games are purely speculative and by no means a substitute for a thorough cost-benefit study. However most of the data are based on realistic assumptions supported by scientific work produced at the Centres. Such speculation may at least help to formulate a hypothesis. The case also emphasizes the question regarding which is the most cost-effective model for implementing IPM. It is clear that benefits from IPM research cannot be demonstrated if an effective extension system is non-existent. This raises the question as to whether Centres are sufficiently well equipped as institutions to be able to effectively engage in 'downstream' activities or should they leave this to others. The evidence available so far is insufficient to permit this question to be answered.

Summary

The case studies presented above do not cover the entire range of impacts that can be expected from IPM. However, these are cases where either economic impact studies have been conducted or other evidence of economic relevance exists. To conclude, at least three more studies are worth mentioning as they included IPM-related activities in their analysis. These studies are from CIMMYT: one on crop management research and two related to breeding.

In the first study (Traxler and Byerlee 1992) IPM was one of the two out of nine crop-management innovations adopted by wheat farmers in Mexico. Based on subjective evidence, farmers have adopted the key aspects of the IPM programme and have considerably reduced insecticide use after a period of five years. The IRR to the crop-management research investment has been carried out using various assumptions. It was found to be in the range of 11 to 23% depending on what percentage of the extension costs were included. These rates of return are on the lower end of estimated rates of return to agricultural research but in this particular case, the costs of innovations that were not adopted were included. If only the investment in IPM is taken then the rate of return is 100%, mainly because the message produced by research was simple "don' t spray prophylactically". This study is good for drawing conclusions as to the deductions that have to be made from rates of return for 'purely' research investments and those that would be obtained if all investment were included.

In the worst scenario the true rate of return is probably one fifth of that based on research only. For the rates of return on IPM it seems plausible to treat IPM in the context of overall crop management. In most of the cropping systems in developing countries one can assume the existence of some gap in technical and allocation efficiency. Crop management innovations can help to overcome these by increasing yield or quality of crop product and in some cases decreasing inputs. The effect of IPM technologies is either to reduce crop loss and/or to reduce unnecessary crop protection inputs, which in most cases are pesticides. It seems realistic to assume that farmers are interested in both increasing yield and reducing loss and likewise are interested to learn how to use costly inputs efficiently.

Therefore, under 'real life' conditions IPM is likely to be introduced in combination with other crop-management practices that would result in a lower rate of return compared to those IPM investments where farmers are confronted with a pest crisis. Such investments are of a 'fire-brigade nature'. They are not investments in pest management but rather in pest control. These usually pay off if the 'fire can be extinguished early enough'.

Against this it has to be taken into account that more often than not pest crisis is the result of misguided crop-management practices. Therefore, what are treated as benefits in investment aimed at overcoming a pest crisis are actually externalities of prior human interference. This phenomenon, described by Cowan and Gunby (1996) as "path dependency in pest management" helps to inflate the rate of return on IPM investments, as in the above case of biological control of the cassava mealy bug. Yet it is clear that this cannot be the yardstick for measuring the true economic impact of IPM nor can it be the strategy of the members of the System-wide Programme on IPM, known as the 'IPM group' in the long run to tackle only such cases. Rather it must be to prevent emergency cases that lead to artificially high rates of return.

Thus it is concluded that the long-term rate of return to investments in IPM is in the order of magnitude of 15 to 40%, rather than over 100% as found in the pest crisis case. This is the same conclusion as that reached for resistance breeding in wheat. The analysis of Byerlee and Traxler (1995) for the joint CIMMYT/NARS breeding system showed that if only yield maintenance benefits of wheat improvement research in the post-green revolution period are considered then the IRR is 37%. Smale *et al.* (1998), in their study of the economic impact of breeding for resistance to leaf rust in wheat, showed the IRR in relation to the variable 'yield loss prevented' and 'research lag'. When yield losses are high (50%) and the research lag is short (five years) the rate of return was close to 100%. When losses are low (10%) and the research lag is high (10 years) the IRR dropped to just over 10%.

These examples make clear that a high rate of return in pest control is not an indicator of successful crop/pest management, it can also be the opposite. If investments in IPM are designed to prevent pest crisis these invariably become joint crop-management research investments. Trying to single out the share of IPM in this combination would not make much sense. The objective of public crop research clearly should be to optimize the entire crop-management system rather than to maximize the share of IPM. Although the rates of return that can be obtained from crop-management research that includes IPM components can be interpreted as lower band. IPM helps to reduce negative externalities of pesticides on humans and the environment. These effects are often excluded from economic analysis because of the difficulty in measuring such effects, nevertheless although they are often excluded from economic analysis they should be treated as an additional benefit.

7 Conclusions

This study has dealt with a complex issue based on sparse information and under less than optimal conditions with regards to available time. However, some conclusions with some degree of validity can be drawn. This requires looking again at the purpose of the study, which is: *'to provide evidence for the efficient use of the public funds that were invested by the Centres in IPM'*.

As pointed out in the introduction this does not mean conducting a formal social cost-benefit analysis. This was impossible because there are just too many programmes. Few can provide the kind of data necessary to conduct such an analysis, neither have they previously been subjected to an economic analysis. However, neither was the approach that which is sometimes used in economics, i.e. claiming that investments in producing and maintaining all macro-economists pay-off well because John Maynard Keynes and Milton Friedman have produced such tremendous benefits to society by avoiding catastrophic recessions and rampant hyperinflation (Smith 1998). Applying this principle in this study would have meant using the most successful case studies with demonstrated economic benefits and then checking whether *'this sun shines strong enough to spread its warming rays on all entomologists, plant pathologists and weed scientists in the Centres who have ever dealt with IPM'*.

The approach used was to establish different classes of indicators believed to be helpful in testing whether research on IPM has been successful. We started with soft indicators, i.e. those based on a participatory self-assessment process with respondents from the Centres labelled earlier as 'IPM champions'. From there we gradually moved to more 'hard' indicators by analyzing the quantity and type of published materials. Then we subjected the perceptions expressed by the respondents from the Centres with the opinions of their clients and partners, and finally we tried to apply scrutiny to some of the available economic case studies. Based on this evidence it is possible to arrive at certain conclusions and to see what key questions remain.

The body of evidence

The survey, which is based on questionnaires sent to Centres, depicts a blend of facts and perceptions. Therefore, respective indicators must be considered as soft. However, some conclusions can be drawn.

Firstly, it can be said that research on IPM has existed in all Centres for a long time. This is not normality because little funding comes from the Centres' core budget. However, IPM at the Centres is definitely more than just a fashionable catchword to attract donor funding. Scientists working in IPM have taken the original idea of the "integrated control concept" (Stern *et al.* 1959) seriously and put their efforts into providing alternatives to the plant-protection products of the private sector, as shown by the high emphasis given to resistance breeding and biological control. Hence, the broad definition of IPM as a technology that can help to move pesticide use in developing countries towards their social optimum was relevant.

Secondly, despite differences in interpreting the concept, the technological paradigm of IPM is dominant but there is also increasing appreciation given to treating IPM – as is suggested by the term 'management' – in a social-science context. Thirdly, the future of IPM is perceived as being dependent on developments in biotechnology that will determine the nature of future partnerships. In this regard, there is a tendency for Centres to increasingly regard the plant protection products of the private sector as being complementary to the development of 'their' IPM technology. This may change the direction away from producing 'alternative goods' in pest management to 'intermediate products' as part of a broader IPM concept. This has a positive and a negative side. The questions that arise from this challenge are discussed in the last part of the section.

Moving to the next level of indicators, the lists of publications on IPM, these underline the high profile of this subject area. A large proportion of publications are journal articles. This suggests that the IPM work carried out at the Centres is accepted in the scientific community. Maybe this is related to the nature of the publications, many of which deal with component research. IPM research that deals with fundamental ecological or social science questions occurs less often judging by the titles. The implications of this could be that while the Centres' IPM work is well known among the narrower professional society, it is less well known with partners involved in implementing IPM field programmes.

Looking at the evolution of titles, the conclusions drawn from the survey are confirmed. The high frequency of biological control topics and the low frequency of chemical control topics confirm that IPM was really looking for alternatives to chemical pesticides. On the other hand, the rather low frequency of crop loss and other basic studies supports the technical perspective of IPM. By and large, one could conclude that while there are high quality publications on how pest problems can be solved there is less evidence that the ecological, economic and social factors that influence pest management decision making at farmers' level are well understood. A judgement based on IPM publications would assume that little is known as to whether, and how, farmers are changing their methods of pest management. Exploring the possible relationship between 'publication success and field success' supports this conclusion. In short, this relationship does not seem to exist.

Some programmes have high journal impact points and others low impact points although the Centres often rate them as being equally successful. Putting the evidence supplied by publications together it appears that the high professional quality of IPM research is beyond any doubt but the linkage to pest control by farmers remains an open question. In other words, it is unclear from the perceptions and the facts presented by the Centres how successfully the results of research could contribute to higher-level objectives such as lowering the cost of food security.

Some enlightenment can be drawn from looking at the viewpoint of clients as a 'harder' indicator of impact. While the clients expressed satisfaction with the Centres' IPM products, at the same time they are asking for some change. Except for the private sector, whose objectives presumably differ from those of the multilateral and bilateral development organizations, partners want IPM at the Centres to become more field orientated. Clients do not view this as being in contradiction with high-quality research work. On the contrary, they see a need to better integrate methodology and field work, i.e. to draw conclusions on methodology from working together with local researchers, extension staff and farmers. The perceptions, which were expressed by the respondents to the survey in the Centres, do not fully reflect the expectations of their NGO and public-sector clients. The expected dominance of biotechnology in pest management seems to lead them to a path different from past IPM research. This raises the strategic question, IPM *quo vadis*?

There is little doubt that past investment in IPM has been profitable. Whenever economic impact studies have been conducted they show similar rates of return to those for investment in other agricultural research. On the other hand, studies of failures could not be traced.

However, there are good reasons why investment in IPM research should have a high payoff. Firstly, IPM is often called in when farmers are confronted with a crisis situation – sometimes the result of pests or pesticides – and when private-sector technologies have either failed or are unavailable. Such investments are of a 'fire-brigade nature' which usually pay if the 'fire can be extinguished early enough'. As there is no indication that misguided human interference in the ecosytem will diminish on a global scale, there is likely to be a continuing demand for this type of IPM.

The second type of IPM is integrated in crop-management research. It is reasonable to assume that the demand for this type of IPM will also continue and may even exceed that of a crisis nature. Given the numerous institutional constraints, especially the degree of information exchange, the existence of considerable gaps in terms of technical and allocation efficiency in most cropping systems in the developing world seems to be a plausible assumption. IPM, in the context of overall crop-management improvement, has a good potential to narrow such gaps. The effect of IPM is either to reduce crop losses and/or to reduce unnecessary crop-protection inputs, in most cases pesticides. Farmers are interested in increasing yield and reducing loss, as well as learning how to use costly inputs efficiently.

It is likely that IPM, when used in crop-management improvement, will have lower rates of return, probably about one fifth of the rate of return in crisis situations, because its success very much depends on the existence of an effective extension model. That being said, however, such rates of return are at a level not achieved by many other investments in agriculture.

Another reason why the benefits of investment in IPM are high and in principle tend to be underestimated rather than overestimated in economic analyses is that IPM can reduce negative externalities from chemical pesticides. A good example is the costs incurred by farmers and other groups in society through intoxication or residues in food caused by toxic chemicals. The studies of Rola and Pingali (1993) and Crissman (1994) have shown that for occupational health such costs cannot be ignored. IPM, through the provision of alternatives to toxic chemicals, can reduce these costs and this should be accounted for as a benefit. Other externalities, such as water contamination and loss of domestic animals and wildlife, have not been well documented for developing countries. However, a study in Thailand (Jungbluth 1996) showed that externalities from pesticides expressed as a ratio of external costs to the amount spend on pesticides is in the order of 1:1. For the US, the famous Pimentel *et al.* study (1993) put this ratio at 2:1 and a study by Waibel *et al.* (1999) for agriculture in Germany came up with a ratio of 0.23:1. The latter study in particular shows that even in a country where strict pesticide laws exist, at least on paper, IPM programmes can produce benefits that go beyond those from improving crop-management efficiency. These cases support the hypothesis that additional benefits accrue from investment in IPM in developing countries.

Comparing both types of investment there is some temptation for the 'IPM group' to go for investment in IPM for use in crisis situations, which is in fact what they did mostly in the past. However, such a race for the 'golden rate of return' would be at the expense of the real issue. 'Fire brigade investments' are investments in pest control but not in pest management. Pest management in many of the world's cropping systems suffers from dependence on chemical pesticides. Entomologists for a long time have called this 'the pesticide treadmill' (van den Bosch 1967). Such treadmills help to inflate the rate of return on pest control but not for pest management.

These examples make clear that a high rate of return for pest control must not be equated with successful crop and/or pest management. The opposite can also be true; if pest control is highly profitable the cropping system could be in a bad shape. Therefore, the yardstick for measuring the true economic impact of IPM cannot be limited to calculating the rate of return in a static economic efficiency concept. Instead it should capture the feedback mechanisms that human interference such as pest control produces in ecosystems and the interaction between environment and economy. Such a dynamic framework is still constrained by a number of conceptual and methodological problems. However, thinking about it helps to show the limitations that must be recognized in analyzing the rate of return of investment in pest management.

Instead of going for the highest cost-benefit ratio the mission of the 'IPM group' should be to lead the way out of treadmills whenever they exist. Maybe of even more importance in the long run is ensuring that no new treadmills emerge that could attract investments with artificially high rates of return. As pointed out by Herren (1999) if not carefully handled, the expected and partly ongoing biotechnological revolution could generate such a new treadmill.

Available evidence and experience from the past, and the human capital that exists within and outside the Centres, should make it possible to achieve this. Public crop research must optimize the entire crop-management system rather than maximize the share of IPM. Here the objectives not only of farmers, but also of society, must be taken into account.

To conclude, analysis of the body of evidence on the impact of IPM suggests that investments on IPM in the Centres have paid off and will continue to pay off if the right decisions are made. The rates of return, as demonstrated in many of the studies however, may be somewhat lower in reality. Probably the long-term rate of return to investments in IPM is in the order of magnitude of 15 to 40%, rather than over 100% as seen in the pest-crisis case. It seems reasonable to place these in the order of magnitude of rates of return from investments in maintenance breeding as studied by Byerlee and Traxler (1995).

Nevertheless, it is important to point out that investment payoff is not only dependent upon good research. As the study on the economic impact from breeding for resistance to leaf rust in wheat of Smale *et al.* (1998) has shown, much depends on the timelag between the research product and its final adoption in farmers' fields. This is also the message that can be drawn from the hypothetical simulation of rice IPM in Asia. As the timelag grows between excellent research being carried out and its adoption by farmers, then the power of the discount rate also depreciates the net value of IPM research.

The remaining questions

There are two basic questions that remain after this analysis: firstly whether from the Centres' point of view investments in IPM will continue to pay-off as was the case in the past; and secondly, in what direction should the IPM group go. It is clear that both questions are related and that extrapolations from past developments cannot be made. As pointed out by one of the interviewees from the private sector: "The world has changed and it is a new game now".

Rather than trying to answer these questions, which would anyhow not be possible on the basis of available information, some of the 'paradoxes' that emerged during the study will be highlighted. There are four major paradoxes where some discussion might be useful for strategic planning of IPM activities at the CGIAR-level

The first concerns the *information environment* that underpins the Centres' IPM activities. As was shown by the analysis of publication titles, studies on crop loss are not 'extremely popular' in the IPM group. Yet, and as clearly pointed out in Chapter 3 of the IFPRI publication on "Pest Management and Food" (Yudelman *et al.* 1998) there does exist the paradox of increased pesticide use and at the same time increased losses from pests. Why do crop losses increase, in relative terms, despite rising levels of pesticide use in many of the world's crops, better and more effective pesticides, high-quality scientific research on plant protection, more knowledge about pest management and, last but not least, by and large successful (albeit often only pilot) programmes on IPM.

If such a situation really exists, Dr John Wightmann, former 'IPM champion' at ICRISAT asks in a letter to IFPRI: "why then does the international agricultural community, e.g. the CGIAR System not invest substantially more money in IPM?". With the assumption that such investment would pay off much better than other research it is worthwhile looking at the source of this information on crop loss, also cited in the IFPRI publication. The methodology used in that study (Oerke *et al.* 1994) – which was sponsored by German chemical companies – was to base crop loss estimates on the attainable yield instead of the economic yield. Furthermore, while the harvest taken by pests was defined as 'loss' the costs of preventing crop loss were not. Most importantly, the sources of data were overwhelmingly pesticide trials from the companies' experimental stations. Why, until now, has the IPM group from the Centres not made an attempt to verify these absolutely crucial assumptions by considering an alternative approach to crop-loss assessment, e.g. based on crop physiology science?

The second paradox deals with the question *whether IPM is not rather a social science*? Looking at the publications, IPM appears to be high-quality research on pest-control tactics. Supposedly, this has been done ever since plant protection existed as a science. Originally an entomologist's concept (Stern *et al.* 1959) it was developed to avert dependency on chemical pesticides and to make them the last resort after all other measures have failed (FAO 1967). The Centre's publications show that serious attempts have been made to provide alternatives to chemical pest-control tactics but what remains highly unclear is whether this has changed the way farmers control pests beyond anecdotes and pilot projects. From the comments of many of the Centres' clients, it seems that the call for participatory field orientation of IPM research and its practical application cannot be overstressed. If more emphasis were placed on improving the basic understanding of the factors that hinder or augment IPM in farmers' fields would IPM become a social science concept ? .

The third paradox is the *private sector question.* Traditionally the linkages between researchers who develop plant protection products of the pesticide (now called life science) companies have been strong. Although IPM was originally developed to offer an alternative to a chemical pest-control strategy driven purely by the private sector the chemical companies quickly embraced it, at least on a rhetorical basis. The terms 'rational' and 'judicious' pesticide use (implying that there must be irrational and injudicious pest control) were adopted and become 'rational IPM' (implying that there must be irrational IPM). However, it is common knowledge in economic welfare theory that the profit motives of private agents do not necessarily lead to a socially desirable outcome. Why would the private-sector companies award their salesmen for selling 20% less pesticides. While it is well recognized that the issue is not as simple as this, the fact that the private sector is not able to sell its private 'IPM good' implies that he must use IPM in a way that supports sales of plant-protection products if they want to recover investment in IPM.

With the emergence of biotechnology much of the discussion on private/public-sector partnership in relation to agricultural development and food production is between chemical companies and public agricultural research. At the same time, much of the current generation of biotechnology is in the field of pest management. Why then are IPM issues and biotechnology not treated together and why does the IPM group not draw more heavily from the lessons learned from chemical pesticides when discussing biotechnology? Lastly, why does the discussion not concentrate on scientific standards as a pre-condition for talks on partnerships and exploring more thoroughly the true benefits of biotechnology in the light of alternatives.

The fourth paradox is that *policy and institutional analysis* so far only plays a minor role in IPM. Even in their questionnaires the Centres rarely mentioned policy and institutions (with few exceptions, e. g. ISNAR who predicted that the institutional question would gain in importance). IFPRI convened a meeting on IPM in 1995 (see Yudelman *et al.* 1998) and again in 1998 with high-level experts from industry and academia but on neither occasion were any of the Centres' active 'IPM champions' or a representative of the CGIAR secretariat present (or invited?). The role of IPM and pesticide policy is being discussed as a policy case study (Norton and Alwang 1998) at IFPRI' s impact assessment meetings on measuring the impact of social science research. However, no linkage exists between the technology side of IPM and the necessary policy and institutional environment that could facilitate a more rapid adoption of IPM'. Why is there no attempt by the CGIAR System to work towards policies conducive to IPM, integrated in agricultural and environmental policy? Related to this is the fact that some of the clients/partners of the Centres see Centres' role as also being that of an 'honest broker' who can help NARES to make appropriate selections from the 'basket of technology' which is being 'filled' by different players (e.g. the private sector, NGOs, universities, etc.). Should proper guidance not include getting the policy right? How are the Centres going to meet this challenge?

8 Recommendations

It is difficult to make recommendations based on a study dealing with impact assessment, in this case of IPM research at the Centres. However, because of the questions that emerged during the study and the paradoxes that seem to exist with the issues around IPM, three recommendations are made.

Firstly, more economic case studies on the impact of science-based, public-sector IPM technologies should be carried out. The System wide Programme on IPM has made a good start on a number of cross-cutting topics (Annual Report 1997/98) and this could serve as a focal point for such activity. At the same time, the methodology of IPM impact assessment could be further advanced. Schemes such as those developed and tested by ISNAR (Loevinsohn *et al.* 1998) should be explored further.

There is a need to take impact evaluation beyond the short-term income effects and to include an assessment of the natural resource implications of IPM and the long-term effects on farmers' innovative and problem-solving capacity, together with institutional implications. As the participatory approach to IPM becomes stronger, the effects of IPM on building up social capital should receive special attention. Here methods of contingent valuation, now widely applied in the field environmental assessment, could be tested. Links with other groups engaged in IPM evaluation should be established inside and outside the System.

Within the CGIAR, links with the System-wide Programme on Participatory Research and Gender Analysis would be useful. A framework comprising possible dimensions of impact evaluation of IPM is presented in Figure 10. Here IPM evaluation is not purely a 'with and without income effect question' but is treated more as a process of building up evidence. Increasingly, IPM impact assessment at the Centres must include inputs provided by partners in extension, be they NARES or NGOs. There is little merit in trying to separate the value of research from those of extension.

The second recommendation is to make a serious attempt to tackle the crop-loss paradox. Exaggerated loss figures do have a significant political dimension because they stimulate ad-hoc investment in loss reduction measures. More often than not loss reduction measures are carried out under the banner of insurance in view of perceived catastrophic situations.

Unless more valid estimates of crop loss are available there is no rational basis for designing a global strategy of loss-reduction research and of strategies to improve global food security. This is very much a question of the conceptual basis of crop-loss assessment. In the past, crop-loss assessment was carried out to show how high looses due to pests are. Therefore, a general weakness of these estimates is that they are mostly derived from artificial conditions comparing unrealistic alternatives. For example, in studies of crop protection, data are based on experimental station conditions with pesticide evaluation trials (Oerke *et al.* 1993) using the most susceptible varieties. However, what would be more important for research planning is to generate a better understanding of the factors that affect yield and yield variability.

Also, often, the true costs, especially the external costs of loss prevention measures are being ignored. However, since food security is neither a matter of only production nor of prices but a matter of production costs, loss estimates need to be translated into economic loss if loss-reduction measures are going to contribute positively to food security. Thus a link must be established between crop loss, IPM and food security based on good science.

The third recommendation concerns the formulation of a System-wide IPM strategy. This proposal was strongly supported by multilateral and bilateral development organizations and NGOs. The purpose would be twofold: (1) to establish a clearer vision about what can be expected from IPM; and (2) to ensure that donors, clients and partners know what can be expected from IPM research at the Centres.

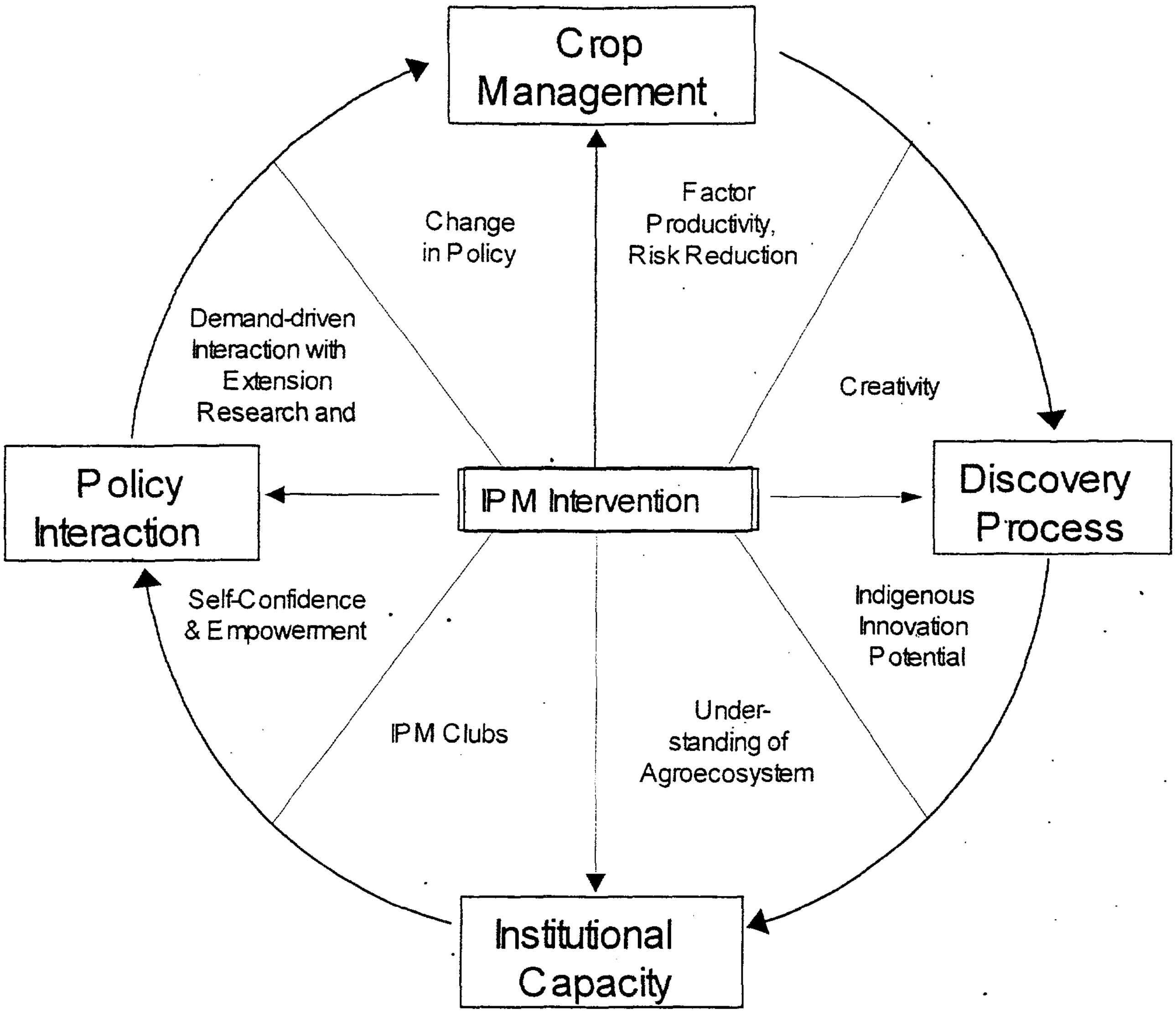

Figure 10 Conceptual framework for evaluation of IPM

In addition to the specified purpose, and as suggested by one of the respondents, the development of a strategy should be guided by three main questions:

- ***What is the Centres' comparative advantage*** The Centres as a group should analyse their weaknesses and strengths in IPM relative to what others are doing. Based on that their mode of collaboration with partners should be clarified to reduce the transactions costs of collaboration. The possibility of establishing Centre-specific technology communication groups or even Inter-Centre Technology Development and Transfer Groups (similar to what ICRAF is trying to do) should be explored.
- ***Who are the key partners***? Centres must demonstrate and document clearly with whom and on what basis they want to collaborate. This is also related to the question 'upstream', 'downstream' or 'both'. For 'upstream' the terms, principles and (scientific) standards on which partnerships with the private sector are to be undertaken must be set up System-wide. The benefits (funding, knowledge products) and the risks (image loss, loss of 'bio-diversity' in science) should be carefully assessed. For 'downstream' a new approach to science needs to be given more attention. The "research from the ground" (The Economist, 18.09.99) requires more openness and service orientation as demanded by some of the Centres' clients. But it also requires the rethinking of traditional research paradigms and the evaluation of existing reward systems for Centre scientists and professional staff. To find the optimal mix will be a major challenge, which must be decided by the Centres individually.
- ***What is the way forward for collaboration?*** This question has been asked in the interviews with clients and partners. In principle, the categories are contract research, participation in field projects, provision of consultants, and formal and informal information exchange. It is recommended that in IPM the Centres describe their 'products' more clearly and develop a marketing strategy that can not only help to attract clients but also make transactions with partners easier.

To conclude, if the 'P' in IPM is used more to denote 'people' rather than 'pest' then IPM can move away from the 'language of loss' and enter the world of efficiency and sustainability. 'IPM champions' should not be too much afraid of such a move.

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Appendix 1: Questionnaire sent to the Centres

I. Questions related to the history of IPM

1. When did the Centre label an activity as IPM for the first time? What kind of programme was it and in which year? (Please refer to evidence in the respective annual report)
2. Did this first initiative lead to immediate follow-up activities? If yes, which ones and if no, when was the next initiative undertaken?
3. Describe your most successful IPM activities preferably providing appropriate evidence.
4. When was resistance breeding included in the Centre's crop breeding programme?
5. Please estimate the relative share in the Centre's budget allocation for IPM-related activities, from the first initiative up to the present:

Year	Field programs	Resistance Breeding	IPM Methodology	Others (add columns if necessary)
19..				
19..				
19..				
19..				
19..				
19..				
19..				
19..add rows if necessary...				

Questions related to the current status of IPM at the Centre

1. Do IPM activities affect the overall research, development and training activities of your Centre (e.g. IPM mission statement, IPM guidelines for centre activities in the Centre's research farm etc.)?
2. What is currently the share of unrestricted core funding allocated to IPM activities?
3. Who are currently your major NARES partners with whom you carry out country-specific (or regional) IPM activities? (Please list names, affiliations and country)
4. Are you collaborating with NGOs in IPM ? If yes, please specify which ones and explain the type of collaboration.
5. Are you collaborating with commercial sector partners in IPM ? If yes, please specify which ones and explain the type of collaboration.
6. With respect to your Centre's other programmes, do you see special benefits and/or special difficulties with IPM activities? If yes, please specify.

Questions related to the future of IPM initiatives

1. During the next five years, in the context of the Centre's activities, will the relative importance of IPM initiatives (a) decrease, (b) stay the same, or (c) increase? Please elaborate as appropriate.
2. For your Centre where do you see the major need for IPM activities in the coming decade (e.g. research, training, field implementation, policy)? Who do you consider to be your major partners in future IPM initiatives
3. Do you expect a change in the nature of partnerships for your future IPM activities?

Appendix 2: Additional Interviews (by phone) with potential and actual clients of the CG-Centres

No.	Organisation	Name	Date
1	FAO	Peter Kenmore	9.8.99
2	USAID	Walter Knausenberger	12.8.99
3	World Bank	Doug Forno	12.8.99
4	CARE	Mario Pareja	13.8.99
5	GTZ	Petra Mutlu	13.8.99
6	Zeneca	Mike Whitaker	17.8.99
7	CRISP(US-AID)	S. K. De Datta &collegues	17.8.99
8	Novartis	Jakob Brassels & colleague	18.8.99
9	Monsanto	Paul S. Teng	20.8.99
10	CARE	Carlos Perez	30.8.99
11	EU- DG12	Alain Darthenucq	3.9.99
12	Norvartis-Foundation	Klaus Leisinger	9.9.99
13	CABI-IIBC	Jeff Waage	14.9.99
14	World Resources Institute	Lori Ann Thrupp	14.9.99

Appendix 3: Questions discussed with CG-Centre client organisations

Questions

A Relating to past and on-going contacts with the Centres

1 Please list the CG-Centres with which your organisation has collaborated most during the past ten years

2 What type of collaboration was this ? (e.g. contract research, participation in projects, expertise, information exchange)

3 How would you rate the importance of the Centres relative to other sources of technology in IPM (information exchange, collaboration, etc)

4 How satisfied were you with the contributions made by the CG-Centers when you requested/used their "IPM-products" (technologies) in your IPM projects

B Questions relating to the future of IPM of the CG-Centres

1 From the viewpoint of your organisation where do you see the future role of the CG-Centres in advancing IPM in developing countries.

2 Do you think Centres should invest substantially more money in IPM ? Explain !

3 Should the Centres concentrate more on methodological issues or should they participate more in field implementation of IPM projects. In case of the latter explain their role ?

4 Do you see a need for a co-ordinated Center-IPM strategy ? If yes, what would be your recommendation in implementing such a strategy ?

5 Any other comment

Appendix 4: Major NARES partners in Centre-IPM activities

Centre	Region	Country	Organisation
AVRDC	Asia	Thailand	Department of Agriculture (Bangkok), Kasetsart University (Bangkok)
		Malaysia	Malaysian Agricultural Research and Development Institute (MARDI) (Serdang, Selangor)
		Indonesia	Central Research Institute for Horticulture (Jakarta), Research Institute for Vegetable (RIV)
		Philippines	Department of Agriculture (Manila), Bureau of Plant Industry (Los Banos), Philippine Council for Agricultural and Natural Resources Research and Development (Los Banos), University of the Philippines (Los Banos), Central Luzon State University (Munoz)
		Cambodia	Department of Agronomy (Phnom Penh)
		Laos	Ministry of Agriculture (Vientiane)
		Vietnam	Ministry of Agriculture and Rural Development (Hanoi), Research Institute for Fruit and Vegetables (Hanoi)
		Bangladesh	Hortcultural Research Centre-Bangladesh Agricultural Research Institute (Joydebpur)
		Bhutan	Ministry of Agriculture (Thimphu)
		India	Indian Council of Agricultural Research (New Delhi), Indian Institute of Horticultural Research (Bangalore)
		Nepal	Nepal Agricultural Research Council (Kathmandu)
		Pakistan	National Agricultural Research Centre (Islamabad)
		Sri Lanka	Department of Agriculture (Kandy)
CIAT	Latin America	Brazil	CNPMF (Centro Nacional de Pesquisa en Mandioca y Fruticultura)- Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) Several Centers
		Colombia	CORPOICA (Corporación Colombiana de Investigación Agropecuaria)
		Ecuador	INIAP (Instituto Nacional de Investigación Agropecuaria)
		Cuba	IISV (Instituto de Investigaciones de Sanidad Vegetal)
		Haiti	PRONATHAR (Programa de Frijol de Haiti)
		Mexico	CINVESTAV (Centro de Investigación y de Estudios Avanzados), INIFAP (Instituto Nacional de Investigaciones Forestales y Agropecuarias)
		Guatemala	ICTA (Instituto de Ciencias y Tecnologías Agrícolas)
		Belize	NPPS (National Plant Protection Service)
		El Salvador	CENTA (Centro Nacional de Tecnología Agropecuaria)
		Costa Rica	CATIE (Centro Agronómico Tropical de Investigación y Enseñanza)
		Honduras	EAP (Escuela Agrícola Panamericana)
		Guatemala	PROFRIJOL (Programa de Frijol Centro Americano), INIA (Instituto Nacional de Investigación Agraria)
	Africa	Uganda	NARO (National Agricultural Research Institute)
		Kenya	KARI (Kenya Agricultural Research Institute)
		Tanzania	TARO (Tanzania Agricultural Research Organization)
		Malawi	LARS (Lunyangwa Agricultural Research Station)
		Sudan	ARC (Agricultural Research Corporation)
		Rwanda	ISAR (Institut des Sciences Agronomiques du Rwanda)
		Ethiopia	AREO (Agricultural Research Organization of Ethiopia)
	Asia	China	CATAS
		Japan	JIRCAS

Centre	Region	Country	Organisation
CIMMYT	Latin America	Argentina	INTA
		Mexico	
		Columbia	
		Peru	
		Brazil	
		C. America	
	Asia	Bangladesh	BARI
		Thailand	
		China	
		Philippines	
		India	ICAR
		Nepal	
		Iran	AREEO
		Pakistan	PARC
	Africa	Kenya	
		Zimbabwe	
		Ethiopia	
		Malawi	
CIP	Latin America	Bolivia	Instituto Boliviano de Tecnologia Agropecuaria (IBTA), Proyecto de Investigaciones de la papa (PROINPA)
		Peru	Instituto Nacional de Investigaciones Agropecuarias (INIA), Servicio Nacional de Sanidad Vegetal (SENASA), Programa Nacional de Manejo de Cuencas Hidrograficas y Conservacion de Suelos (PRONAMACHS). Ministerio de Agricultura, Instituto Superior Tecnologico Publico de Cañete (ISTPC). Ministerio de Educación, Municipalidad de Apata, Jauja.
		Ecuador	Instituto nacional Autonomo de Investigaciones Agropecuarias (INIAP), Departamento Nacional de Proteccion Vegetal (DNPV), Programa Nacional de Raices y Tuberculos (PNRT-PAPA), Unidad de Validación y Transferencia de Tecnologia (UVTT).
		Colombia	Instituto Colombiano Agropecuario (ICA), Corporacion del Instituto Colombiano (CORPOICA), Unidad Municipal de Asistencia Tecnica Agropecuaria (UMATA), Servicio Nacional de Aprendizaje (SENA), Municipio de Motavita
	Caribbean	Cuba	Instituto Nacional de Investigaciones de Viandas Tropicales (INIVIT), Centro de Produccion de Entomogenos y Entomopatogenos (CREE)
		Dom. Republic	Programa Nacional de Manejo Integrado de Plagas (MIP), Secretaria de Estado de Agricultura (SEA)
	Northern Africa	Tunisia	Institut National de la Recherche Agronomique de Tunisie (INRAT)
		Egypt	Plant Protection Research Institute, Agricultural Researh Center, Ministry of Agriculture, Dokki,Giza, Egyt.
	C-East Africa	Uganda	National Agricultural Research Organisation (NARO,Uganda)., The Natural Resources Institute (NRI)

Appendix 4 (continued): Major NARES partners in Centre-IPM activities

Centre	Region	Country	Organisation
ICARDA	West Asia	Morocco	INRA
		Tunisia	INRAT
		Ethiopia	EARO
		Egypt	ARC
	North Africa	Syria	DASR, Aleppo University
		Yemen	AREA
		Iran	PPDRI
		Turkey	Cukurova University
ICRISAT	Asia	India	India Council of Agricultural Research (ICAR), state agricultural university in India,
		Nepal	Nepal Agricultural Research Council
		Bangladesh	Bangladesh Agricultural Research Council
		Vietnam	Vietnam Agricultural Science Institute (VASI)
		Indonesia	Research Institute for Legume and Tuber Crops
		Pakistan	Pakistan Agriculture Research Council
	Africa	West Africa	Member Countries of the West and Central African Sorghum Research Network (WCASRN)
		Mali	IER
		Burkina Faso	INERA
		Southern Africa	SADC member countries
ICIPE	Asia	China	CAAS (Chinese Academy of Agricultural Sciences)
		Sudan	AOAD (Arab organisation for Agricultural Development), University of Gezira
		Ethiopia	Government of the Regional State of Benishanul and Gumuz, Ethiopia Science and Technology Commission, PPI (Permaculture and Parasitology Institute)
		Zimbabwe	PPRI (Plant Protection Research Institute), DR&SS (Department of Research and Specialist Services)
		Kenya	JKUAT (Jomo Kenyatta University), KARI (Kitale and HQ Nairobi), MOADLM (Ministry of Agriculture, Livestock and Marketing), KETRI (kenya Trypanosmiais Research Institute), KEMRI (Kenya Medical research Institute), National Irrigation Board and Division of Vector-Borne Disease-Ministry of Health
		Malawi	DAR (Department of Agricultural Research
		Tanzania	Horticultural research and Training Institute Plant Protection Division, Ministry of Agriculture, Livestock and Natural Resources,
		Uganda	KARI (Kawanda Agricultural Research Institute), NARO (National Agricultural research Organisation), Makerere University,
		Zanzibar	Plant Protection Division, Ministry of Agriculture, Livestock and Natural Resources
ICLARM	SE-Asia	Bangladesh	Department of Agriculture Extension, Bangladesh Fisheries Research Institute

Appendix 4 (continued): Major NARES partners in Centre-IPM activities

Centre	Region	Country	Organisation
ICRAF	Africa	Kenya	Kenyatta University, Nairobi; National Agroforestry Research Centre at Maseno, Kenya Forestry Research Institute; Regional Research Centre, Embu, Kenya Agricultural Research Institute
		Rwanda	Institute des Sciences Agronomiques du Rwanda, Butare
		Zambia	Msekera Regional Research Station, Chipata; Ministry of Agriculture, Food and Fisheries
		Tanzania	Agricultural Research and Training Institute, Tumbi, Tanzania Forestry Research Institute
IITA	Virtually all sub-Sahara countries (see Annual Report of PHMD for details)		
ILRI	Africa	Ethiopia	Ministry of Agriculture
		Burkina Faso	CIRDES (Bobo-Dioulasso), INERA, SPRA (Sissili Province)
		Côte d'Ivoire	Ministry of Agriculture and Animal Resources
		Gambia	ITC (Banjul)
		Zimbabwe	RTTCP
		Congo	Centre de Recherche Energie Nuclleaire (CREN-Kin)
		(Kinshasa)	Veterinary Laboratory, Compagnie J.Van Lancker
		Kenya	Brentec Laboratories (Nairobi), KETRI (Nairobi)
ISNAR	Asia	Indonesia	Ministry of Agriculture, National IPM Program
	Africa	Kenya	Kenya Agricultural Research Institute, Ministry of Agriculture and Livestock
WARDA	NARES of WARDA member countries (Please see attached list of projects)		
IPGRI	Country specific IPM activities are planned in the framework of regional networks but have not yet started. Evaluation of improved germplas, as a component of IPM, is however being carried out in around 40 countries worldwide		

Appendix 4 (continued): Major NARES partners in Centre-IPM activities

Centre	Region	Country	Organisation
IRRI	Asia	Bangladesh	Bangladesh Rice Research Institute (BRRI), Bangladesh Agricultural Research Council (BARC), Department of Agricultural Extension (MOA)
		Burma	Agricultural Research Institute
		Cambodia	Department of Agronomy and Plant Protection (Research and Extension), MAF
		China	Chinese Academy of Agricultural Sciences (CAAS), Zhejiang University (dept. of Plant Protection), Zhejiang Academy of Agricultural Sciences (ZAAS), China National Rice Research Institute (CNRRI), Yunnan Academy of Agricultural Sciences (YAAS), Beijing Agricultural University, Hunan Plant Protection Services (extension, Changsa), Hunan Hybrid Rice Research Centre (Changsa), Zhongsan University (Guangzhou), General Station of Plant Protection (Extension, Beijing), Jiangsu Academy of Agricultural Sciences Nanjing
		India	Indian Council of Agricultural Research (ICAR), Directorate of Rice Research (Hyderabad), Tamil Nadu University (Combatoire), Narendra Deva University of Agriculture (Faizabad), Indira Gandhi Agricultural University (Raipur), Rajendra Agricultural University (Bihar), Bidhan Chandra Krishi Viswavidyalaya University (W Bengal), Central Rice Research Institute (Cuttack), Plant Biotechnology Unit, Department of Molecular Biology and Genetic Engineering, CBSH, GBPUA & T, Pantnagar, 263 145, Assam Agricultural University, Jorhat 785 013 (Assam)
		Indonesia	Rice Research Centre (Sukamandi), Bogor Research Institute for Food Crops, Food Crop Protection Centre (Bali), Maros research Institute for Maize and Cereals (South Sulawesi), Directorate of Food Crop Protection (Pasarminggu)
		Korea	Rural Development Authority (Suweon), Gyeong Sang University (Chinju), Yeongnam Crop Experimental Station (Yeongnam)
		Laos	Ministry of Agriculture (Research and Extension)
		Malaysia	Malaysian Agricultural Research Institute (MARDI), Department of Agriculture (Extension), University of Science Malaysia, Muda Agricultural Development Authority (Extension), University of Malaya
		Nepal	National Agricultural research Centre, Institute of Agriculture and Animal Sciences (Tribhuvan University)
		Pakistan	Pakistan Agricultural Research Council
		Philippines	Philippines Rice Research Institute (PhilRice), National Crop Protection Centre (University of the Philippines), Visayas State College of Agriculture (ViSCA, Leyte), Mariona Marcos State University (Illocos Norte), Central Luzon University (Munoz)
		Sri Lanka	Rice research and Development Institute (btalagoda)
		Thailand	Department of Agriculture (+Extension), Chiangmai University, Khon Kaen University
		Vietnam	Cuulong Delta Rice research Institute (Omon), Institute of Agricultural Sciences (IAS), Plant Protection Department (PPD, Extension), Provincial Plant Protection (Extension) department in Long An, Cantho University, National Institute of Plant Protection (NIPP), University of Agriculture and Forestry (UAF), Vietnam Central Institute for Agricultural Sciences (Hanoi)
	Africa	Egypt	Rice Research Centre (Giza)
		Madagascar	FOFIFA (Agricultural Research Institute)
	L. America	Brazil	EMBRAPA

Appendix 5: Collaboration with NGOs

Centre	Region	Country	Organisation	Project
AVRDC[12]	–	–	–	–
CIAT	Africa	Rwanda	World Vision and CARE	Transfer of IPM Technologies for soil-born pathogens of beans
		Uganda	AFRICARE and CARE	
		Kenya	ABLH (Association for better land husbandry)	
	L. America	Colombia	Universidad Nacional de Colombia, Universidad del Valle (Cali), Universidad de Sucre, Universidad de la Amazonia, Universidad de Los Llanos, FIDAR (Fundación para la Investigación y Desarollo Agrícola), CRIVA (Consejo Regional Indígena de Vaupés), FEDEARROZ, FUNDAAM; PROICAR; CENIPALMA; ASOCOFLORES	
		Venezuela	FUNDARROZ	
		Peru	DANAC	
		Brazil	Universidad de Brasilia, Universidad federal do Ceara	
	Asia	China	South China University of Tropical Agriculture	
CIMMYT			Sasakawa Global 2000 World Vision others	Maize and wheat germplasm are distributed to NGOs
ICARDA	West Asia	Lebanon	Green Line	
ICRISAT	Asia	India		the IFAD-IPM project on IPM of legumes in central India is collaborating with 16 NGOs
ICRAF	–	–	–	–
IPGRI[13]	–	–	–	–
ICIPE	Africa	ICIPE collaborates with a numerous amounts of NGOs in Kenya, Tanzania, Ethiopia, Eritrea, Zambia and Zimbabwe		Neem-Awareness
		Kenya	Catholic Church	Small scale irrigation and IPM technologies

[12] Only few contacts with NGOs, mainly through the program in Thailand, Bangladesh and Tanzania. However regional programs have extensive contacts with NGOs who test AVRDC germplasm for yield and other characters including disease resistance. NGOs are often included in the incountry and headquarter training program

[13] *In some countries NGOs are involved in evaluating improved, disease resistant germplasm supplied by INIBAP*

Appendix 5 (continued): Collaboration with NGOs

Centre	Region	Country	Organisation	Project
CIP	Caribbean	Dominican Republic	Junta Agroempresarial de Consultoria y Coinversion, Inc. (JACC). Fundacion de Desarrollo Agropecuario (FDA).	IPM implementation in Unit Pilot IPM implementation in Unit Pilot
	Latin America	Bolivia	Proyecto Irpa Tayka de Radio San Gabriel (PIT-SRG). La Paz.. Proyecto Sukakollus (PROSUKO). La Paz. Vision Mundial. La Paz. Ilglesia Metodista Evangelica. La Paz. Intervida. La Paz..	IPM diffusion
		Peru	Grupo de Investigacion y Desarrollo de Ciencia Andina (TALPUY). Huancayo. Laicos Unidos Contra la Pobreza (REDES). HuancayoInstituto Valle Grande. Cañete.	IPM implentation in Pilot Units.
			CARE-PERU. Proyecto ALTURA.. Lima. Red de Accion de Alternativas a los Agroquimicos (RAAA). Lima. IPM diffusion. ADRA-OFASA. Huancayo	IPM diffusion.
		Ecuador	Programa de Fortalecimiento de Investigacion y Producción de semilla de papa (FORTIPAPA). Vision Mundial.	IPM implementation in Unit Pilot IPM diffusion
ICLARM	SE-Asia	Bangladesh	Jagorani Chakra	Aquaculture Extension
		Philippines	Community Forestry Project Quirino (bilateral project DENR/GTZ)	Supporting environmentally friendly farming techniques, including the establishment of rice terraces and facilitates IPM training
			Antique Untegrated Agriculture Develop-ment Foundation (ANIAD)	partner in a PhD study
IITA	Africa		Sasakawa Global 2000 CARE World Vision IITA houses the secretariat for the CG-NGO IPM committee (Africa)	
ILRI	–	–	–	–
IRRI	Asia	Bangladesh	Proshika	Analysis of arthropod communities in organic rice
		Thailand	PDA	Evaluation of including IPM as part of a primary school curriculum in NE (Thailand)
		Davao	TACDRUP	Evaluation of pest-natural enemy balance in organically grown rice and insecticide free rice
ISNAR	Africa	Kenya	Kenya Institute of Organic Farming (KIOF)	Evaluation
WARDA	–	–	–	–

Appendix 6: Journal Impact Factors

Name of Journal	Abb.	Impact Factor
Acarologia	Ac	0,013
Acta Entomologica Bohenmoslovaca	AEB	0,146
Acta Oecologia	AO	0,543
Acta Tropica	AT	1,431
Agricultural Engineering	AgE	0,086
Agricultural History	AHY	0,016
Agricultural Systems	AgS	0,474
Agricultural Water Management	AWM	0,258
Agriculture Ecosystem & Environment	AEE	0,738
Agroforestry Systems	AS	0,152
Agronomie	A	0,421
Agronomy Journal	AJ	0,686
AMBIO	AMB	1,232
American Journal of Agricultural Economics	AJA	0,472
Angewandte Botanik	AB	0,324
Animal Genetics	AG	2,151
Animal Production	AP	1,004
Animal Reproduction Science	ARS	0,855
Annals of Applied Biology	AAB	0,405
Annals of the Entom. Society of America	ASA	0,689
Annual Review of Entomology	ARE	6,477
Annual Review of Phytopathology	ARP	4,106
Anz. fuer Schaedlingsk. Pfl.schutz Umw.sch.	ASP	0,068
Applied and Environmental Microbiology	AEM	3,175
Applied Entomology and Zoology	AEZ	0,302
Archives of Insect Biochem. and Physiology	AIB	1,669
Archives of Virology	AV	1,223
Australian Journal of Agricultural Research	AJA	0,784
Biochemical Genetics	BG	0,726
Biochemical Systematics and Ecology	BSE	0,746
Biocontrol Science and Technology	BST	0,581
Biologia Plantarum	BP	0,168
Biological Agriculture & Horticulture	BAH	0,15
Biology and Fertility of Soils	BFS	0,908
Biometrical Journal	BJ	0,165
Biometrics	B	1,207
Bioorganic & Medical Chemistry Letters	BMC	1,425
Biotropica	BIA	0,872
Bulletin of Entomological Research	BER	0,709
Canadian Entomologist	CE	0,482
Canadian Journal of Botany	CJB	0,788
Canadian Journal of Microbiology	CMB	1,29
Canadian Journal of Plant Pathology	CJP	0,573
Canadian Journal of Plant Science	CPS	0,407
Canadian Journal of Zoology	CJZ	0,736
Cereal Research Communications	CRC	0,102
Chemische Berichte	CBE	1,983
Chemistry and Industry	CIY	0,423

Appendix 6 (continued): Journal Impact Factors

Name of Journal	Abb.	Impact Factor
Comparative Biochemistry and Physiology B	CBP	0,685
Conservation Biology	CB	1,643
Crop Protection	CP	0,441
Crop Science	CS	0,648
Current Microbiology	CM	0,983
Current Science	CSC	0,271
Discovery and Innovation	DI	0,041
Ecological Economics	EcE	1,313
Ecological Entomologist	EE	0,972
Ecological Modelling	EM	0,683
Ecology	EC	2,818
Entomologia Experimentalis et Applicata	EEA	0,831
Entomologia Generalis	EG	0,146
Entomophaga	EN	0,248
Environmental Entomologist	EnE	0,882
Euphytica	E	0,579
Evolution	Ev	2,349
Experientia	EX	1,615
Experimental Agriculture	EA	0,518
Experimental and Applied Acarology	EAA	0,434
Field Crops Research	FCR	0,642
Food Reviews International	FRI	0,417
Forest Ecology and Management	FEM	0,583
Genetics	GNS	4,871
Genome	G	1,623
HortScience	HS	0,435
Insect Biochemistry & Molecular Biology	IBM	1,694
Insect Science and its Application	ISA	0,065
Insectes Sociaux	IS	0,642
International Journal of Pest Management	JPM	0,023
International Journal of Systematic Bacteriology	IJS	3,431
Japanese Journal of Appl. Entomol. and Zool.	JJA	0,169
Journal of Agricultural Entomology	JAg	0,267
Journal of Agricultural Science	JAS	0,621
Journal of Agriculture and Food Chemistry	JAF	1,342
Journal of Animal Ecology	JAn	2,517
Journal of Applied Ecology	JAE	1,013
Journal of Applied Entomology	JEn	0,325
Journal of Chemical Ecology	JCE	1,048
Journal of Comparative Physiology	JCP	1,517
Journal of Dairy Science	JDS	1,394
Journal of Economic Entomology	JEE	0,943
Journal of Environmental Management	JMT	0,354
Journal of Environmental Science and Health Part B	ESH	0,693
Journal of Eucariotic Microbiology	JEM	2
Journal of Experimental Biology	JEB	1,82
Journal of General Virology	JGV	3,478
Journal of Heredity	JH	1,533

Appendix 6 (continued): Journal Impact Factors

Name of Journal	Abb.	Impact Factor
Journal of Infectious Diseases	JID	4,781
Journal of Insect Behaviour	JIB	0,882
Journal of Insect Physiology	JPh	1,461
Journal of Invertebrate Pathology	JIP	0,996
Journal of Medical Entomology	JME	1,134
Journal of Natural Products	JNP	1,498
Journal of Nematology	JNY	0,585
Journal of Parasitology	JoP	1,031
Journal of Phytopathology	JP	0,348
Journal of Stored Product Research	JSP	0,44
Journal of the Amer. Mosquito Control Assoc.	MCA	0,5
Journal of the Science of Food a. Agriculture	JSF	0,866
Landscape Ecology	LE	0,767
Livestock Production Science	LPS	1,133
Maydica	M	0,56
Medical and Veterinary Entomology	MVE	0,773
Molecular and Cellular Probes	MCP	1,773
Mycologia	MYA	0,879
Mycotaxon	MN	0,382
Nature	Na	25,466
Nematropica	N	0,214
Netherlands Journal of Plant Pathology	NJP	0,419
New Scientist	NST	0,318
Oecologia	O	1,366
Outlook on Agriculture	OA	0,339
Parasitology	Pa	1,836
Parasitology Research	PR	0,898
Pesticide Science	PS	0,904
Phil. Trans. R. Soc. Lon.B	PTR	2,19
Physiologia Plantarum	PHP	1,507
Physiological and Molecular Plant Pathology	PMP	1,354
Physiological Entomology	PE	0,892
Phytochemistry	P	1,157
Phytoparasitica	Pp	0,438
Phytopathology	PH	2,222
Plant and Soil	PaS	0,714
Plant Breeding	PB	0,6
Plant Cell Tissue and Organ Culture	PCC	0,745
Plant Disease	PD	0,676
Plant Foods for Human Nutrition	PFH	0,168
Plant Pathology	PP	0,873
Preventive Veterinary Medicine	PVM	0,555
Proceedings of the Royal Soc. of London B	PRS	2,79
Research in Veterinary Science	RVS	0,727
Research on Population Ecology	RPE	0,31
Scientia Horticulturae	SH	0,458
Scientia sinica Series B	SSB	0,183
Seed Science and Technology	SST	0,161

Appendix 6 (continued): Journal Impact Factors

Name of Journal	Abb.	Impact Factor
Sociobiology	S	0,358
Spectroscopy Letters	SL	0,341
Tetrahedon Letters	TL	2,378
The Florida Entomologist	FE	0,387
The Veterinary Quarterly	VQ	0,547
Theoretical and Applied Genetics	TAG	2,536
Therioginology	T	1,967
Tropical Agriculture	TA	0,098
Tropical Animal Health and Production	TAH	0,193
Tropical Grasslands	TG	0,139
Tropical Medicine and Parasitology	TMP	0,73
Tropical Pest Management	TPM	0,069
Veterinary Parasitology	VP	0,864
Virus Genes	VG	1,716
Weed Research	WR	0,445
Weed Science	WS	0,67
Weed Technology	WT	0,306
Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz	ZPP	0,208

Appendix 7: Summary of all IPM related Journal Publications cited by the Centres

Name of Journal (Journal Impact Factor*)	Centres (please see names below)										
	1	2	3	4	5	6	7	8	9	10	11
A (0.421)					1	1					
AAB (0.405)			1		2	1		3		4	
AB (0.324)					1						
Ac (0.013)						1					
AEB (0.146)						2					
AEE (0.738)		2						6		4	
AEM (3.175)										4	
AEZ (0.302)	1					6				4	
AG (2.151)									1		
AgE (0.086)										1	
AgS (0.474)									2	3	
AHY (0.016)										1	
AIB (1.669)						2					
AJ (0.686)								1		1	
AJA (0.472)									1		
AJA (0.784)	1									1	
AMB (1.232)									1		
AO (0.543)						2					
AP (1.004)									4		
ARE (6.477)		2						1		2	
ARP (4.106)			1							4	
ARS (0.855)									1		
AS (0.152)							11			2	
ASA (0.689)						1				1	
ASP (0.068)						1					
AT (1.431)						4			14		
AV (1.223)					1						
AWM (0.258)										1	
B (1.207)								1			
BAH (0.15)											1
BER (0.709)		3			1	18		11	2	12	
BFS (0.908)											1
BG (0.726)										1	
BIA (0.872)										1	
BJ (0.165)						1					
BMC (1.425)	1										
BP (0.168)										1	
BSE (0.746)						3					
BST (0.581)						7		15		1	
CB (1.643)									1		
CBE (1.983)										1	
CBP (0.685)						8					
CE (0.482)								2			

* from the "Journal Citation Reports" published by ISI (institute for Scientific Information) 1994

Appendix 7 (continued): Summary of all IPM related Journal Publications cited by the Centres

Name of Journal (Journal Impact Factor*)	Centres (please see names below)										
	1	2	3	4	5	6	7	8	9	10	11
CIY (0.423)										1	
CJB (0.788)								1			
CJM (1.29)										1	
CJP (0.573)		1	2								
CJZ (0.736)						1					
CM (0.983)						2					
CMB (1.29)										1	
CP (0.441)		1	2			5		9		45	1
CPS (0.407)					1						
CRC (0.102)			4								
CS (0.648)	1	4	12		5	1				11	
CSC (0.271)										1	
DI (0.041)						8					
E (0.579)	6	4	15		2			1		1	1
EA (0.518)					2					3	
EAA (0.434)		1				9		14			
EC (2.818)										2	
EcE (1.313)									2		
EE (0.972)						3		2			
EEA (0.831)		3				17		10		14	
EG (0.146)						1					
EM (0.683)				1		2		2			
EN (0.248)	5	1			1	2		4		1	
EnE (0.882)		2	2			5		8		37	
ESH (0.693)										1	
Ev (2.349)						1					
EX (1.615)										1	
FCR (0.642)					2	1	1	1		1	2
FE (0.387)		3	1								
FEM (0.583)							1				
FRI (0.417)										1	
G (1.623)			2						1	1	
GNS (4.871)										1	
HS (0.435)	1							1			
IBM (1.694)						1					
IJS (3.436)										1	
IS (0.642)						1					
ISA (0.065)	4	3	2	1		93		26	1	27	
JAE (1.013)						2		3	1	1	
JAF (1.342)	1							1			
JAg (0.267)		1			1					9	1
JAn (2.517)						1					

* from the "Journal Citation Reports" published by ISI (institute for Scientific Information) 1994

Appendix 7 (continued): Summary of all IPM related Journal Publications cited by the Centres

Name of Journal (Journal Impact Factor*)	Centres (please see names below)										
	1	2	3	4	5	6	7	8	9	10	11
JAS (0.621)									1	2	
JCE (1.048)						14				3	
JCP (1.517)						1					
JDS (1.394)									1		
JEB (1.82)						1					
JEE (0.943)	22	3	2		1	5				42	
JEM (2)						1					
JEn (0.325)						11		5		4	
JGV (3.478)		1									
JH (1.533)						1					
JIB (0.882)						3				1	
JID (4.781)									1		
JIP (0.996)						3		3		1	
JJA (0.169)						1				1	
JME (1.134)						13					
JMT (0.354)										1	
JNP (1.498)						2					
JNY (0.585)										1	
JoP (1.031)						1					
JP (0.348)	3	2			7					3	
JPh (1.461)						7					
JPM (0.023)	3				1	7		4		10	4
JSF (0.866)						1					
JSP (0.44)			1			1		4		2	
LE (0.767)									1		
LPS (1.133)									2		
M (0.56)			3			6					
MCA (0.5)						2					
MCP (1.773)						1					
MN (0.382)										1	
MVE (0.773)						13			1		
MYA (0.879)										1	
N (0.214)				2				1			
Na (25.45)						1					
NJP (0.419)			1		4					1	
NST (0.328)										1	
O (1.366)						1					
OA (0.339)								1	1		
P (1.157)						8					
Pa (1.836)						5					
PaS (0.714)										3	
PB (0.6)			6					1			

* from the "Journal Citation Reports" published by ISI (institute for Scientific Information) 1994

Appendix 7 (continued): Summary of all IPM related Journal Publications cited by the Centres

Name of Journal (Journal Impact Factor*)	Centres (please see names below)										
	1	2	3	4	5	6	7	8	9	10	11
PCC (0.745)										1	
PD (0.676)	16	7	14		4			13		19	
PE (0.892)						5					
PFH (0.168)								1			
PH (2.222)	6	5	4					9		31	
PHP (1.507)										4	
PMP (1.354)										2	
Pp (0.438)						2					
PP (0.873)								2			
PR (0.898)						9					
PRS (2.79)								2			
PS (0.904)								1			
PTR (2.19)											
PVM (0.555)						2			8		
RPE (0.31)										8	
RVS (0.727)									1		
S (0.358)						1					
SH (0.458)	1										
SL (0.341)								2			
SSB (0.183)										1	
SST (0.161)								2		4	
T (1.967)									1		
TA (0.098)	1					4		1	4	1	
TAG (2.536)	1	2	3		1					8	
TAH (0.193)						3			6		
TG (0.139)		5									
TL (2.378)						2					
TMP (0.73)						5					
TPM (0.069)	4	3	2		1			3		13	
VG (1.716)		1									
VP (0.864)						9			8		
VQ (0.547)									1		
WR (0.445)										2	2
WS										3	
WT (0.306)								1		1	
ZPP (0.208)										1	

* from the "Journal Citation Reports" published by ISI (institute for Scientific Information) 1994

List of Centres

1 = AVRDC

2 = CIAT

3 = CIMMYT

4 = CIP

5 = ICARDA

6 = ICIPE

7 = ICRAF

8 = IITA

9 = ILRI

10 = IRRI

11 = WARDA

Table 1: Framework of the Centres IPM impact assessment

Level of Evidence	Type of IPM Product				
	Field Programmes	**Paradigm Shifts in Pest Management**	**New Concepts and Methods**	**Human Capacity Building**	**Awareness Building and Changing Policy Conditions**
1	Economic impact published in Internationally refereed Economic Journals	Published in internationally refereed journals, *citation index high*	Published in internationally refereed journals, *citation index high*	National IPM Champions created	Documented policy change (e.g. banning of pesticides)
2	Economic impact published in internationally refereed Non-economic Journals	Published in internationally refereed journals, *citation index medium*	Published in internationally refereed journals, *citation index medium*	IPM related training with evaluation	IPM related policy workshops with documented reaction
3	Economic Impact in unpublished reports	Published in internationally refereed journals, *citation index low*	Published in internationally refereed journals, *citation index low*	IPM related training without evaluation but documented	IPM related workshop/dialogue without measured reaction but with documentation
4	Impact other than economic in internationally refereed Journals	Published in Conference proceedings	Published in Conference proceedings	IPM related training, no documentation	IPM related policy workshop/dialogue without documentation
5	Impact other than economic in unpublished reports	Unpublished reports (working papers)	Unpublished reports (working papers)	no evidence	no evidence
6	claimed but no evidence	claimed but no evidence	no evidence		

Table 2: The start of IPM activities at the Centres

Centre	Year of Establishment	Year of 1st IPM	Evidence
AVRDC	1973	1978	The label "Judicious Pest Management" was first used to describe on-going entomological research on Chinese cabbage
CIAT		1978	Annual Report (Cassava and Tropical Pasture program both report on IPM systems and activities)
CIMMYT	1966	1966	CIMMYT initiated host plant resistance research
CIP	1971	1982	Annual Report within the Entomology-Nematology Thrust (p.63)
ICARDA	1977	1994	Project: "Integrated Management of Diseases and Insect Pests" (see 1994-1998 Medium Term Plan)
ICIPE	1970	1975	Annual Report in 1975 highlighted different IPM research activities
ICLARM	1973	1989	ICLARM Conference Proceedings 28, 1991, "Environmental Impact of the Golden Snail (*Pomacea* sp.) on Rice Farming Systems in the Philippines"
ICRAF	1977	1991	Annual Report, pp 65-66: "Avoiding root-knot nematode damage to nematode-susceptible crops grown in rotation with sesbania fallows.
ICRISAT	1972	1990	Research on IPM components since the early 1970's. In the 1990 Annual Report a full section is devoted to IPM (pages 73-80).
IFPRI	1975	1995	IFPRI-WWF workshop on Pest Management, Food Security and the Environment
IITA	1967	1979	Annual Report ("Integrated Control of cow pea pests")
ILRI	1995	1991	Priority Research Agenda 1991 (Research on Trypanotolerant livestock)
IPGRI	1974	1996	INIBAP Annual Report (p. 40), IPM research on banana weevil borer at CRBP in Cameroon
IRRI	1960	1964	Feasibility Study on "Biological Control of Rice Stem Borers
ISNAR	1979	1997	Study of institutional challenges in participatory NRM R&D
WARDA	1971	1991	Characterization of pest problems, including yield loss assessment and varietal development for host plant resistance

Source: own survey

Table 3: Year of introducing resistance breeding by Centre[1] and crop

Centre	Crop	Year
AVRDC	Mungbean, Tomato, Sweet potato, Crucifers	1972/73
CIAT	Beans	1976
	Cassava	1973
	Rice	1970
	Tropical Pasture	during the 70s
CIMMYT	Maize and Wheat	1966
CIP	Potato and Sweet potato	no date
ICARDA	different Cereal and Legume Crops	1977
ICIPE	Maize, Banana	before 1994
ICRISAT	different Legume Crops	1972
IITA	Maize, Cowpea, Cassava, Banana	early 70s
ILRI	Livestock	1995
IPGRI	Banana	1985
IRRI	Rice	during 60s
WARDA	Rice	1988

Source : own survey

[1] only those Centres who engage in crop breeding are included

Table 4: First IPM programme by crop and Centre*

Crop/Pest	Centre(Year)
Banana *(Musa* ssp.)	IPGRI (1996)
Barley *(Hordeum vulgare)*	ICARDA (1994)
Broad Bean *(Vicia faba)*	CIAT (1982), ICARDA (1994)
Cabbage *(Brassica chinensis)*	AVRDC (1978)
Cassava *(Manihot esculenta)*	CIAT (1977), IITA (1979)
Chickpea *(Cicer arietinum)*	ICARDA (1994), ICRISAT (1996)
Cowpea *(Vigna unguiculata)*	IITA (1979)
Groundnut *(Arachis hypogae)*	ICRISAT (1991)
Lentil *(Lens culinaris)*	ICARDA (1994)
Maize *(Zea mays)*	CIMMYT (1966), ICRAF (1995)
Millet *(Pennisetum glaucum)*	ICRISAT (1992)
Mungbean *(Vigna radiata)*	AVRDC (1980)
Others / Cropping System	
Sesbania ssp.	ICRAF (1991)
Leucaena ssp	ICRAF (1993)
Striga hermonthica	ICRAF (1995)
Imperata cylindrica	ICRAF (1993)
Pigeonpea *(Cajanus caja)*	ICRISAT (1998)
Potato *(Solanum tuberosum)*	CIP (1982)
Rice (Oryza sativa)	IRRI (1964), CIAT (1985), ICLARM (1991), WARDA (1991)
(Oryza glaberrima)	WARDA (1991)
Sorghum *(Sorghum bicolor)*	ICRISAT (1994)
Sweet potato *(Ipomoea batatas)*	AVRDC (1972), CIP (1982)
Tomato *(Lycopersicon esculentum)*	AVRDC (1989)
Wheat *(Triticum aestivum)*	CIMMYT (1966), ICARDA (1994)

* ICIPE, ISNAR and ILRI are excluded from the tables which deal with crop breeding

Table 5: Successful IPM programmes

Centre	Programmes (no ranking)
AVRDC	(1) Mungbean disease control (2) IPM of a crucifer pest (3) Tomato disease control (4) Sweet potato weevil IPM (5) Information exchange (conferences and meetings)
CIAT	(1) Breeding for resistance to bean golden mosaic virus (BGMV) (2) IPM related to control of the cassava hornworm (3) Integrated crop management for rice (4) Tropical Pastures: Resistance to the most important anthracnose disease of the forage legume *Stylosanthes*, discovery of an endophytic fungus in tropical grasses *(Brachiaria brizantha)*
CIMMYT	(1) CIMMYT germplasm project in Africa (Maize streak virus) (2) Collaboration with Kasetsart University (Thailand) to deploy downy mildew resistance in maize (3) Identification of germplasm tolerant to the maize stunt complex (Central America) (4) Incorporating insect pest resistance into maize germplasm (fall armyworm, rootworms, spider mites) (5) Distribute APR resistant wheat materials (6) MTP project "Reduction in post harvest losses"
CIP	(1) Management of sweetpotato weevil in Cuba and the Dominican Republic (2) Management of potato pests in the Andean countries (potato weevil, potato tuber moths and leafminer flies) (3) Two projects with direct involvement of NGOs: CARE's MIPANDES program and the ARARIWA program both in Peru (4) Management of the common potato tuber moth (Northern Africa) (5) Management of sweetpotato pests in Uganda
ICARDA	(1) Integrated disease management packages for chickpea ascochyta blight (2) The use of biological control agents etc. for the control of lentil vascular wilt (3) The integration of sowing date and different cultivars for the control of the lentil broomrape (*Orobranche crenata*) (4) IPM packages to control the chickpea leaf miner and the faba bean necrotic yellow virus
ICIPE	(1) Capacity building in insect science (doctoral fellowships) (2) Integrated pest management of tsetse flies (3) Integrated pest management of food and perennial crop pests (4) Integrated pest management - horticulture
ICLARM	(1) Impact of integrated aquaculture technologies (highlighting weed control, pesticide reduction, increase in rice productivity, reduction in farm labour and the generation of income as benefits to this technology)
ICRAF	(1) Rehabilitation of *Imperata* grasslands through agroforestry (2) Management of *Striga* through sesbania planted fallows and soil fertility replenishment (3) Management of root-knot nematodes in tree fallow-crop rotation systems

Table 5 (Continued): Successful IPM programmes

Centre	Programmes (no ranking)
ICRISAT	(1) IPM package for groundnuts (2) Release of a number of stem-borer resistant sorghums (3) IFAD-supported special project on legume IPM to control insect pests in India
IITA	(1) Resistance breeding against African Cassava Mosaic Virus (ACMV) (2) Resistance breeding against Maize Streak Virus (MSV) (3) Biological control of cassava mealybug (4) Microbial biocontrol of locusts and grass-hoppers (5) Farmer practices for improved control of banana nematodes and banana weevils
ILRI	(1) Tsetse Control in Southwest Ethiopia (2) Trypanotolerance and Chemotherapy in West Africa
IPGRI	(1) Africa-wide workshop on banana IPM in South Africa in November 1998
IRRI	(1) Release of multiple pest resistant varieties (IR26, IR36, IR42, IR46, IR54 onwards) (2) Initiating the international pest and disease testing program (IRTP) (3) Biological control of diseases and weeds (4) Sociological research on IPM
ISNAR	(1) Development and refining a framework and methods based on evolutionary theory to understand how participatory interventions affect farmers' research and their capacity to manage natural resources (2) Use the evolutionary framework in an evaluation of a Farmer Field School project
WARDA	(1) Varietal development and in particular the inter-specific breeding program of rice (selections do have host plant resistance to a range of indigenous pest problems)

Table 6: Evidence of Integration of IPM in Centres Activities

Centre	Evidence
AVRDC	Development of IPM technology has been an integral part of AVRDC's research since the Centre's establishment in 1973. With the establishment of the AVRDC regional network in 1989, IPM training courses and field programmes were undertaken
CIAT	The concept of IPM is implicit in the Centre's philosophy of sustainable natural resource management. The IPM philosophy and activities are integrated into CIAT's overall goals purposes and outputs. In general the role of IPM and ICM has become more central to the various projects in CIAT's project portfolio
CIMMYT	IPM activities are one of the central planks in research and training at CIMMYT. In wheat, MTP Global Project 6 "Developing wheat germplasm for biotic stress environments", in maize MTP Project 4 "Developing maize germplasm for biotic stress environments" and in training , MTP Global Project "Human resource development".
CIP	The IPM programme has a very intensive training programme. There are many other activities like field days, which are not registered as formal training. Most IPM work is conducted in farmer fields, in localities where pest problems are particularly serious.
ICARDA	IPM activities have an overall effect on research, development and training activities of ICARDA. The IPM mission statement has been adopted and crop rotation is used to control pathogens at the ICARDA farm. The training programme includes annual IPM courses.
ICIPE	ICIPE's mandate was from the very beginning dedicated to IPM. In general Centre activities embrace research and training in tropical arthropod science for development. Current activities focus on improving and promoting human, animal, plant and environmental health, by interdisciplinary teams of scientists
ICLARM	IPM is not a major thrust for ICLARM but is considered as part of the benefits of the introduction of aquaculture into farming systems. This introduction is dependent upon the reduction or elimination of pesticide use.
ICRAF	Most field research is conducted on farms, so although there is no IPM guidelines, the general emphasis is on no or minimum pesticide use.
ICRISAT	IPM has certainly been an influential concept in research planning and management across the institute. However ICRISAT has never organized itself to include IPM as a formal programmatic/structural entity.
IITA	IPM is a key element in the research and development strategy of the institute
ILRI	It is the principle guiding research on integrated health management
IPGRI	IPM is a key activity of INIBAP regional networks and features in the strategic plan of these networks
IRRI	IPM is the guiding concept for research and training at IRRI. The practice guidelines for the farm are based on IPM principles where sprays are only applied when thresholds are reached. In 1989, the farm banned the use of category I pesticides and placed category II pesticides on restricted use.
ISNAR	IPM activities do not affect the overall research, development and training activities of the Centre.
WARDA	IPM is a major theme within WARDA's research and training activities. Among the task forces the IPM task force is the largest. WARDA's task forces are the major instrument of WARDA's interactions with NARES. WARDA is an active member of the SP-IPM program and is a convening centre for one of the initiatives.

Table 7: Current and previous research budget allocated to IPM activities

Centre	Current (1998)		1995		1990	
	%	US $ (1000)	%	US $ (1000)	%	US $ (1000)
AVRDC	30-40		30-40		30-40	
CIAT	6,03		6,21		5,72	
CIMMYT		3 921		3 889		2 805
CIP	-	-	-	-	-	-
ICARDA	7		5		-	
ICIPE	6-7	270-300	-	-	-	-
ICLARM	-	-	-	-	-	-
ICRAF	0,6	54	-	-	-	-
ICRISAT	15		15		15	
IITA	38	9 294		10 501		4 975
ILRI	-	-	-	-	-	-
IPGRI	76*	3 054		1 545		445
IRRI	20,7					
ISNAR	0,8		-	-	-	-
WARDA	5		-	-	-	-

* Including support to resistance breeding.

Table 8: Previous and current Allocation of the IPM budget (reporting Centres only) in %

Centre	Current (1998)				Previous (< 1995)			
	Field Programme	Resistance Breeding	IPM Methodology	Capacity Building	Field Programme	Resistance Breeding	IPM Methodology	Capacity Building
AVRDC	6	31	63	-	-	33	67	-
ICARDA	14	43	43	-	-	80	20	-
ICRAF	68[1]	-	-	-	71[2]	-	-	-
ICRISAT	20	50	30	-	20	50	30	-
IITA	40	14	22	24	41	13	26	21
IPGRI	-	95	2	3	-	100	-	-
WARDA	41	18	41	-	-	100	-	-

[1] Remaining 32% allocated to synthesis of and identifying policy.

[2] Remaining 29% allocated to synthesis of and identifying policy.

Table 9: Major NARES partners in Centre-IPM activities

Centre	Region	No. of Partner Countries	No. Government Res. Departments	Research Institutes	Universities	Total Collaboration in Research	No partners in Gov. Extension Work
AVRDC	Asia	13	8	11	3	22	-
CIAT	L. America	12	-	15	-	15	-
	Africa	7	-	7	-	7	-
	Asia	2	-	2	-	2	-
CIMMYT	L. America	6					
	Africa	4					
	Asia	8					
CIP	L. America	4	3	14	-	17	-
	Africa	3	1	4	-	5	-
	Caribbean	2	-	2	-	2	-
ICARDA	Asia	4	-	4	-	4	-
	Africa	4	-	3	2	5	-
ICRISAT	Asia	4	-	6	1	7	-
	Africa	> 4[1]					
ICIPE	Asia	1	-	1	-	1	-
	Africa	8	7	9	3	19	-
ICLARM	Asia	1	-	-	-	-	1
ICRAF	Africa	4	1	8	-	9	-
IITA	Africa	[2]					
ILRI	Africa	7	2	6	-	8	-
IPGRI		40[3]					

[1] All SADC member countries and members of the West and Central African Sorghum Research Network (WCASRN).
[2] Virtually all Sub-Saharan countries.
[3] Country-specific IPM activities are planned in the framework of regional networks but have not yet started. Evaluation of improved germplasm, as a component of IPM, is however being carried out in around 40 countries worldwide.

Table 9 (cont.)

Centre	Region	No. of Partner Countries	No. Government Res. Departments	Research Institutes	Universities	Total Collaboration in Research	No partners in Gov. Extension Work
IRRI	L. America	1	-	1	-	1	-
	Africa	2	-	2	-	2	-
	Asia	15	3	30	19	52	9
ISNAR	Asia	1	1	1	-	2	-
	Africa	1	1	1	-	2	-
WARDA	Africa	16					

Table 10: Collaboration with NGOs

Centre	Region	No. of partner countries	No. of collaborating NGOs
AVRDC[1]	-	-	-
CIAT	L. America	4	16
	Africa	3	4
	Asia	1	1
CIMMYT		>3	unspecified
CIP	L. America	3	12
	Caribbean	1	2
ICARDA	Africa	1	1
ICRISAT	Asia	1	16
ICIPE	Africa	6	unspecified
ICLARM	Asia	2	2
ICRAF	-	-	-
IITA	Africa		3
ILRI	-	-	-
IPGRI[2]			
IRRI	Asia	3	3
ISNAR	Africa	1	1
WARDA	-	-	-

[1] Only few contacts with NGOs, mainly through the programme in Thailand, Bangladesh and Tanzania. However regional programmes have extensive contacts with NGOs who test AVRDC germplasm for yield and other characters including disease resistance. NGOs are often included in the incountry and headquarter training programme.

[2] In some countries NGOs are involved in evaluating improved, disease resistant germplasm supplied by INIBAP.

Table 11: Collaboration with the private sector

Centre	Company	Country	Project
AVRDC		Asia	Private seed companies receive AVRDC's disease-resistant germplasm. Seed companies use the material in breeding disease resistant vegetable varieties which are sold to the farmers.
CIAT	AGREVO; DOW	Colombia	Evaluation of entomopathogens in IPM systems in beans
	Novartis		Agreement for Cooperative biotech in IPM systems, e.g. resistance in CIAT commodity crops and maize to pests and pathogens
	Monsanto		Round-up resistance genes for cassava
	Companía Agrícola	Colombia	IPM of vegetable crops
	BIOCARIBE	Colombia	Collaboration in research and development of biopesticides
CIMMYT	not specified	not specified	Supply host-plant resistant maize; provide wheat germplasm to national seed companies
CIP	–	–	–
ICARDA	Novartis		Testing BION, a synthetic compound for seed treatment and foliar spray, as a component in the integrated management of chickpea Ascochyta blight.
ICRISAT	–	–	–
ICIPE	FPEAK	Kenya	(Fresh Produce Exporters Association of Kenya) "Towards biologically intensive pest management: Metarhizium anisoplae for the Management of Thrips in high value horticulture." (Kenyan Flower Council) Collaborative activities with KFC for IPM
	KFC	Kenya	"Financing Neem Extract Project": involving the purchasing of seeds, leaves and barks of the
	Saroc Ltd.		neem tree and processing and packing them into officially registered products to be marketed.
ICLARM	–	–	–
ICRAF	–	–	–
IITA	BCP	South Africa	For the commercial production and distribution of a mycopesticide developed by the LUBILOSA
	NPP	France	project to control locusts
	Mycotech	USA	Exchange of information and material
ILRI	Coopers	Zimbabwe	Commercial drug companies are supporting research on integrated trypanosomosis and tsetse
	Shering-Plough	Belgium	control in Ethiopia
	Brentec Laboratory	Kenya	Contribution to genetics research and developing new diagnostic techniques
IPGRI			Commercial companies are testing improved germplasm supplied by INIBAP
IRRI	Novartis		Bt rice materials had been received (but no collaboration with the commercial sector on IPM activities)
ISNAR	–	–	–
WARDA	–	–	–

Table 12: Importance of IPM in the next five years

Centre	Decrease	Same	Increase	Remark
AVRDC			X	Increased efforts in finding alternative sustainable control measures are required because pesticide cultivation in developing countries is unacceptably high
CIAT			X	CIAT is expected to participate in an External Programme and Management Review and to prepare a new Strategic Plan. These events could influence CIAT's role in and support of IPM activities.
CIMMYT			X	IPM presents the most cost-effective, safe, and sustainable manner to minimize the impact of diseases. Biotechnology is expected to contribute significantly to the development of durable resistance genes from diverse sources.
CIP		X		Any increase will depend on the availability of funds from special projects.
ICARDA		X		It is unlikely that core support to IPM will be increased. Any future expansion would rely on special project funding. It is not easy to predict how successful ICARDA will be in attracting more funding for IPM, but they are optimistic.
ICRISAT		X		Much depends on donor interest as ICRISAT's core continues to decrease and special project support increases as a proportion of the total budget.
ICIPE		X		ICIPE will not involve itself in IPM work of insect pests for cereal or legume crops but focus in vital augmentative components where it has unique or specialised expertise
ICLARM			X	ICLARM intends to extend the introduction and evaluation of Integrated Acquaculture-Agriculture (IAA) practices into new agroecologies (e.g. humid zone of west Africa). IPM will remain an integral part of aquaculture integration into small holder systems.
ICRAF			X	Emphasis to monitor and assess pest risk (risk assessment guideline), develop an IPM strategy and monitor arthropod diversity
IITA		X		IPM will remain very important.
ILRI			X	Activities should increase as integration of disease-control strategies becomes more firmly embedded in ILRI's research programme, and as guidelines are developed for particular ecological, biophysical and socio-economic circumstances.
IPGRI			X	Particularly in the context of the regional networks, where it is expected that field programmes will be initiated.
IRRI			X	The importance of IPM initiatives will have modest increase in importance at IRRI.
ISNAR			X	Importance of IPM may well increase as ISNAR develops follow-on activities aimed at building national capacity to support better resource management.
WARDA			X	IPM activities will probably increase due to the emphasis that is placed on problems associated with intensification of lowland agriculture, peri-urban areas, and management changes such as direct seeding.

Table 13: IPM needs by type of activity and Centre

Centre	Research and Development	Training	Implementation	Policy
AVRDC	In-house and farmer-participatory research will stay the same	Educational materials based on research results to promote IPM with farmers through policy makers (regulatory agencies) and NARES	see training	see training
CIAT	Emphasis on research and development of IPM components (host plant resistance, biological control) will remain. Additional emphasis on the use of biotechnology	Capacity in farmer participatory research and training should be expanded	Will need to, and should become more involved with IPM implementation to link CIAT's research capacity with NARS and NGOs.	–
CIMMYT	–	–	–	–
CIP	Continue "IPM Pilot Units" strategy : problem assessment, development of components, integration, implementation of pilot units, large scale implementation. Research, training, field implementation are interactive.	see R&D	The emphasis is placed on field implementation. The relative effort on the other activities may be shifted according to knowledge gaps encountered during the implementation phases.	–
ICARDA	same	same	There is a need to make greater move in taking the IPM activities from research plots to farmers' fields	Not directly involved in policy issues, but in awareness building
ICRISAT	Strategic and adaptive research priorities: developing Bt transgenics, mass multiplication of parasites, utilisation of entomopathogens	Same: training partners at different levels; with NARS, conduct training of both extension personnel and farmers.	field implementation is needed through special projects with NARS. Increase farmers' awareness of IPM.	Lesser emphasis on policy.

Table 13 (continued): IPM needs by type of activity and Centre

Centre	Research and Development	Training	Implementation	Policy
ICIPE	Focus on alternative preventive approaches to the control of pests. Improve basic understanding of the bioecology and chemoecology of primary pest outbreaks .	--	Participatory R&D during all phases of implementation.	--
ICLARM	--	Provision of training in living aquatic resource system-specific applications of IPM at the farmer level	Field implementation programmes should take place within the general integration and improvement of aquaculture and the use of irrigated water	--
ICRAF	Major emphasis on strategic and applied research	Training through involvement of graduate and doctoral students in research projects and technicians in the NARES programs	Delivering outputs for farmers in pilot projects for field implementation	--
IITA	Basic research with universities in developed and developing countries as vital partners	Less emphasis on formal short-term training and more emphasis on broader 'capacity-building' efforts with NARES	Field implementation of IPM on mandate crops and wider implementation of classical biological control	Interested in pursuing policy/advocacy work with appropriate partners
ILRI	The major need for IPM activities will continue to be in natural science research. However, understanding how opportunities and constraints in delivering alternate livestock disease control technologies are affected by privatization and liberalization is crucial to gauging prospects for successful integrated disease control.	--	--	Increasing need in the area of policy. To integrate disease control methods in the context of the changes underway in delivery systems for animal health inputs and services in Africa especially
IPGRI		Need for training of extension workers and farmers in techniques and IPM philosophy in general	On-farm testing of existing IPM technologies	--

Table 13 (continued): IPM needs by type of activity and Centre

Centre	Research and Development	Training	Implementation	Policy
IRRI	Ecological : better understand the ecology of new and potential pests and the effects of habitat and landscape diversity, develop new genetic material, better understand pest-crop interactions Sociological : understand farmer's beliefs and decision making, evaluate communication methods, evaluate organizational networks	Ethnoscience training of IPM researchers to facilitate communication skills. IPM training to include curriculum on sociology conducted as graduate course in collaboration with universities.	--	Policy initiatives: establishing dialogue sessions with IPM research and implementation agencies in NARES, Research on pesticide regulation, distribution and marketing
ISNAR		Training and capacity building through action research		Enhancing links between research and policy in : regulation of pesticide hazards , crops genetically modified to express pesticidal properties
WARDA	More adaptive research, and the major partners will	More training	Main partners continue to be NARES in member countries	--

Table 14: Change in partnerships by type of IPM activity

Centre	Research	IPM implementation
AVRDC	More NARES contribution	More NARES contribution
CIAT	Increased involvement with the private sector, universities and advanced research institutes for biotechnology to develop novel approaches in IPM.	Implementation will continue to be with NARs with some shift to NGOs and farmer/processor groups.
CIMMYT	–	–
CIP	no change	no change
ICARDA	–	Closer ties with the commercial sector to enhance field implementation of IPM packages: (formulation of biocontrol agents, mass rearing of natural enemies)
ICRISAT	Increasing involvement of the private sector in relation to biotechnology issues and opportunities	–
ICIPE	no change	no change
ICLARM	–	Only in terms of extending its scope of IAA activities to West Africa
ICRAF	no major change	no major change
IITA	national and within-region organisations should take over a larger share of research	Privately-funded NGOs may develop greater capacity in extension and implementation of IPM direct farmer-researcher interactions are likely to become even more important
ILRI	No major shifts are anticipated	No major shifts are anticipated
IPGRI	No change	No change
IRRI	The partnership will probably involve the public sector, other institutes, donors and NGOs. Such partnerships are likely to be involved in strategic research.	With the public extension sector, FAO and other IC, NGOs and provincial agricultural systems, the relationship will be one of active collaboration, developing joint research agendas etc.
ISNAR	More focused on action-research and capacity building, where now our collaboration focus on more stand-alone research	–
WARDA	No major changes	No major changes

Table 15: Total number of publications on IPM by type and Centre

Centre	Journal Articles	Books/ B.Chapters	Others	Total
AVRDC	129	12	156	**297**
CIAT	98	17	63	**178**
CIMMYT	94	5	52	**151**
CIP	16	1	103	**120**
ICARDA	122	12	103	**237**
ICIPE	464	23	103	**590**
ICRAF	16	1	13	**30**
IITA	237	8	283	**528**
IRRI	1081	-	-	**1081**
WARDA	23	10	42	**75**

Table 16: Number of Journal publications by topics

Centre	Topics									
	Chemical Control	Biological Control	Cultural Control	Crop Loss	Diagnostics	Resistance Breeding	IPM	Ecology	Economics/ Sociology	Total No Journal Articles
AVRDC	8	15	7	4	14	30	1	-	-	129
CIAT	2	22	6	1	18	18	3	3	-	98
CIMMYT	-	-	1	2	1	78	-	-	1	94
CIP	-	-	-	-	-	-	16	-	1	17
ICARDA	-	3	5	8	30	38	-	1	1	122
ICIPE	-	67	11	15	28	29	8	10	10	464
ICRAF	-	-	2	-	1	-	2	-	1	16
IITA	4	85	10	11	17	12	2	4	2	237
IRRI	82	87	59	32	49	125	126	21	55	1081
WARDA	-	-	1	4	5	2	1	-	2	23

Table 17 Number of journal publications by topic (keyword is mentioned in the title)

Centre	Title Categories									Total
	IPM	Environment	Ecology / ecological	Sustainability / sustainable	Biodiversity	Society / social	Economy / economic	Farmer	Food-Production	
AVRDC	2	-	-	-	-	-	-	-	-	129
CIAT	1	-	-	-	4	-	-	-	-	98
CIMMYT	-	1	-	-	-	-	2	1	-	94
CIP	16	-	-	-	-	-	-	-	-	16
ICARDA	-	1	1	2	-	-	1	-	-	122
ICIPE	9	2	9	2	1	1	4	7	2	464
ICRAF	-	-	-	2	-	-	1	-	1	16
IITA	2	1	-	-	-	-	-	1	1	178
IRRI	161	11	8	8	2	1	18	44	1	1081
WARDA	-	-	-	1	-	-	1	2	-	23

Table 18: Successful CIAT programmes in IPM and related publications

Programme	Evidence of Impact	Related Publications		
		Journal Articles		Book Chapters
		No.	*Total Impact Points*[*]	
(1) Breeding for resistance to bean golden mosaic virus (BGMV)	Henry, G. (1990) The Impact of CIAT Bean Technology. Cali, Colombia: CIAT, presented at Annual Review. Pachia, D. (1987) "Impact of improved varieties in bean production in Latin America: A preliminary Review." In: Trends in CIAT Commodities 1987. Cali, Colombia:CIAT.	4	3,477	2
(2) IPM related to control of the cassava hornworm	Henry, G. (1990) The Impact of CIAT Cassava Technology. Cali, Colombia: CIAT, presented at Annual Review. Lyam, J.K., W.G. Janssen, S.A. Romanoff (1986). "From start to finish: Impact Assessment in the Cassava Program." In: Trend Highlights in CIAT Commodities 1986. Cali, Colombia:CIAT.	7	0,704	1
(3) Integrated crop management for rice	Scobie, G. and R.Posada (1977). The impact of high yielding rice varieties in Latin America. Cali, Colombia:CIAT. Scobie, G.M. and R. Posada (1978). "The impact of Technical Change on Income Distribution: The Case of Rice in Colombia." Amer. J. Agr. Econ. 60:85-92.	12	13,498	4
(4) Tropical Pasture: resistance to the most important anthracnose disease of the forage legume *Stylosanthes*, discovery of an endophytic fungus in tropical grasses (*Brachiaria brizantha*)	Sere, C. (1986)."Adoption and Impact Studies: Status and Current Thinking in the Tropical Pasture Program." In: Trends in CIAT Commodities, Cali, Colombia:CIAT. Sere, C. and L.S. Jarvis (1989)."The Betting Line on Beef: Ex Ante Estimates of improved pastures research benefits for the Latin American Tropics." In: C. Sere (ed) Trends in CIAT Commodities, 1989. Cali, Colombia:CIAT:	8	2,48	-
Total Number of CIAT's Publications on IPM		98	-	17

[*] From the "Journal Citation Reports" published by ISI (Institute for Scientific Information) 1994.

Table 19: Successful IITA programmes in IPM and related publications

Programme	Evidence of Impact	Related Publications			
		Journal Articles		Book Chapters	Conference Papers
		No.	*Total Impact Points**		
(1) Resistance Breeding against African Cassava Mosaic Virus (ACMC)	CGIAR impact studies 1998 - notes for CMD (Cassava mosaic disease) in East Africa (Impact of IITA disease-resistant cassava varieties in cassava growing areas of Nigeria)	1	6,48	1	1
(2) Resistance Breeding against Maize Streak Virus (MSY)	-	3	1,55	-	5
(3) Biological Control of Cassava Mealy bug	Neuenschwander, P. and W.N.O. Hammond (1989): Impact assessment of the biological control of the cassava mealybug, Phenacoccus manihoti Matile-Ferrero (Hemiptera: Pseudococcidae), by the introduced parasitoid Epidinocarsis lopezi (De Santis) (Hymenoptera: Encyrtidae). Bull. Ent. Res. 79, 579-594. Neuenschwander, P. (1996): Evaluating the Efficacy of biological control of three exotic Homopteran pests in tropical Africa. Entomophaga 41 (3/4), 1996, 405-424.	42	17,61	2	35
Total Number of IITA's Publications on IPM		240	-	9	254

* From the "Journal Citation Reports" published by ISI (Institute for Scientific Information) 1994.

Table 20: Successful AVRDC programmes in IPM and related publications

Programme	Evidence of Impact	Related Publications: Journal Articles No.	Related Publications: Journal Articles Total Impact Points*	Book Chapters	Conference Papers
(1) Mungbean disease control	Ali, M., A. Malik, H.M. Sabir and B. Ahmed (1997). The mungbean green revolution in Pakistan, Technical Bulletin No. 24. AVRDC, Shanhua, Taiwan, 66p.	11	9,26	-	11
(2) IPM of a crucifer pest (*Plutella xylostella*)	Cardona, E.V. Jr. (1994). Field release of *Diadegmma semiclausum* in the Philippine highlands. In: Collaborative Vegetable Research in SE Asia: Proceedings of the AVNET-I Final Workshop and AVNET-II Joint Planning Meeting, Lembang, Indonesia, 22-26 March 1992, pp272-283. AVRDC, Shanhua, Taiwan. Talekar, N. S., J. C. Yang, M. Y. Liu and P. C. Ong. 1990. Use of parasitoids for the control of diamondback moth, *Plutella xylosteli* *In* O. Mochida, K. Kiritani and J. Bay- Peterson (Ed.), The use of natural enemies to control agricultural pests, FFTC Book Series No. 40, pp 106-114. Food and Fertilizer Technology Center for th Asian and Pacific Region, Taipei, Taiwan.	8	1,24	1	15
(3) Tomato disease control	Green, S. K. (Editor). 1989. Tomato and Pepper Production in the Tropics: Proceedings of the International Symposium of Integrated Management Practices, AVRDC, Shanhua, Taiwan, 619 pp.	24	15,72	3	9
Total Number of AVRDC's Publications on IPM		129	-	12	79

* From the "Journal Citation Reports" published by ISI (Institute for Scientific Information) 1994.