the consultative group on international agricultural research
technical advisory committee

report of
the second tac quinquennial review
of the
international rice research institute
(irri)

tac secretariat
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
THE CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH
TECHNICAL ADVISORY COMMITTEE

REPORT OF
THE SECOND TAC QUINQUENNIAL REVIEW
OF THE
INTERNATIONAL RICE RESEARCH INSTITUTE
(IRRI)

TAC SECRETARIAT
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
December 1982
Mr. Warren C. Baum  
Chairman, CGIAR  
1818 H. Street, N.W.  
Washington, D.C. 20433  
U.S.A.  

August 31, 1982

Dear Mr. Baum:

I have the pleasure to submit to you the report of the Quinquennal Review of IRRI which was conducted last January. The Review Panel was chaired by Dr. A. Blumenschein, who presented the report to TAC at its 28th Meeting at CIMMYT, El Batan, Mexico, in the presence of Dr. C.C. Gray, Chairman of the Board of Trustees, and Dr. M.S. Swaminathan, the new Director-General of IRRI. The Committee noted that the Board of IRRI generally agreed with the findings of the review and it was the intent of the Director-General to take early action on most of the recommendations of the Panel.

On the basis of its discussions, TAC prepared a statement summarizing its own comments and recommendations on the Quinquennial Review of IRRI which is, together with the comments of the Board of Trustees, attached to the Review report.

In submitting to the Group its recommendations regarding the further development of IRRI's activities, the Committee is fully conscious of the broader implications which these may have with respect to the future policies of the Group on the so-called "mature" Centres of the system. The Committee, therefore, draws the attention of the Group to the importance of this issue and seeks the guidance of the Group in this regard. Other main issues requiring discussion by the Group have been outlined in TAC's comments and recommendations and the Committee would appreciate an indication of the Group's views on each of them.

Yours sincerely,

Guy Camus  
Chairman, TAC
TAC COMMENTS AND RECOMMENDATIONS ON THE QUINQUENNIAL REVIEW
OF IRRI FOR CONSIDERATION BY THE CGIAR

INTRODUCTION

1. The report of the second Quinquennial Review of IRRI, attached, encompasses a large number of recommendations and suggestions. The IRRI Board of Trustees has commented on these, as formulated in an earlier draft of the report, as did TAC at its 27th meeting. The report was then revised in the light of these comments, and the revised version was discussed during the 28th TAC meeting with the Chairman of the Board of Trustees and the Director-General of IRRI and the Chairman of the Quinquennial Review Panel.

2. These discussions have been most helpful in clarifying and resolving some apparent differences, and Dr. M.S. Swaminathan has indicated that most of the Quinquennial Review recommendations will be acted on. Many are detailed or managerial matters, which probably require no further discussion by TAC and the CGIAR, but in transmitting this final draft of the Quinquennial Review report, TAC wishes to make several observations as a basis for discussion of the report by the Group in November.

IRRRI'S STANDING AND FURTHER DEVELOPMENT

3. It is abundantly clear from the report that IRRI is an international research centre of the highest calibre and effectiveness. The impact of its work, in broad terms, may be gauged from the executive summary of the Quinquennial Review report (Section 3). Given the magnitude of this achievement, donors may question why IRRI should continue to devote a substantial share of its resources to further work on irrigated and lowland rice systems. TAC wishes to emphasize, therefore, the crucial importance of continuing research if past gains in yield are to be sustained, e.g. to ensure that highly productive varieties with resistance to the unrelenting evolution of new races of pests and diseases continue to be available. The greater the yield level and intensity of cropping already reached, the greater is the need for such research, and the economics of scale and concentration which have made IRRI the lynch pin of the world's rice breeding efforts also apply at least as strongly to the research needed to sustain past gains.

4. Besides such sustaining research, however, there is an urgent need for research aimed at raising yield potential above the level at which it has hovered for a number of years. Although there may appear to be a substantial gap between on-farm yields and those at IRRI, implying ample head room for further increases in farm yields with
present knowledge, in fact this is not always so, as IRRI research has shown. IRRI must therefore be in a position to explore all possible avenues to greater yield and production potential. Since new scientific approaches are continually being generated, new resources - both human and financial - are required to explore them.

5. Many such new activities are discussed and recommended in the Quinquennial Review report (cf. para 541 and e.g. 81, 151, 254, 436), making it clear that IRRI, although over 20 years old and well established must continue to evolve and possibly grow if it is to fulfill its extremely important role. Some priorities for these new activities are indicated in para 542, and these are supported by TAC. Although several areas of past research at IRRI can now be reduced, permitting the transfer of some core funds to new tasks, the resources so liberated are unlikely to match those required for IRRI to undertake all the additional initiatives suggested in the Quinquennial Review report. The new Director-General is reviewing what internal transfers of resources are feasible without harm to important ongoing programmes.

6. As suggested by the Quinquennial Review, some of the new and ongoing activities might be appropriate for special project funding. One such area suggested by the Quinquennial Review is irrigation water management (para 543), but TAC considers that research by IRRI in this area has been so important as indicated in the recent report of the Study Team on Water Management - and is of such long-term nature that it should continue to be mostly supported by core funds unless a new and wider initiative in water management is established.

7. It might also be suggested that the need for IRRI to continue both sustaining and enlarging research on the productivity of irrigated and lowland rice implies a failure on its part to help the national systems to become strong enough to assume these roles. In fact, IRRI has played a key role in the strengthening of many national systems. Where these have attained a certain degree of maturity and sophistication, the earlier relation between IRRI and the national system has changed, but IRRI has continued to support these with more fundamental research, in which it has a comparative advantage. We should not lose sight of the fact, however, that a number of the national rice research systems are likely to remain small and weak for a considerable time.

8. In summary, therefore, the scientific judgement of TAC is that continued growth in the activities of IRRI is justified, albeit at a slower pace, if it is to play its proper and necessary role. TAC recognizes, however, that the feasibility of providing for such growth in the present financial climate is slender, particularly given other requirements for the system as a whole.

THE MANDATE

9. It is evident that the Institute's mandate has not constrained IRRI's research and activities in the past. Although it does not explicitly mention cooperation with national systems in para 3, this has not prevented
IRRI from developing strong and diverse collaborations with many national systems. Likewise, although the mandate does not explicitly mention the maintenance of rice genetic resources as one of its responsibilities, IRRI has assumed this role with considerable effect and distinction, as the new Director-General believes it must continue to do.

10. Our joint discussions made it clear that IRRI will continue to update its interpretation of its mandate, as the Quinquennial Review recommends (para 531). TAC notes that IRRI is currently reviewing its constitution and may wish to make formal changes in its mandate after consultation with TAC and the CGIAR.

11. One highly significant issue relating to the mandate concerns the extent and emphasis of IRRI's geographic role, since this bears directly on its relations with several other Centres - CIAT, IITA and WARDA - which also conduct rice research. TAC considers that even though there may be a need to clarify the relations between these Centres in rice research, the present wording of the mandate - "for the people of Asia and other major rice growing areas" - is appropriate. 90% of the world's rice is grown in Asia, so it is logical that Asian rice growing should be IRRI's primary concern, but it is clear that the other major rice growing regions must also be considered. The present wording of the mandate has the requisite flexibility to accommodate changes in the roles of the four IARCs in rice research, but may need to be modified when the complementary roles of these Centres are eventually determined.

12. The important issue that remains to be clarified is the most effective mechanism for interrelating and coordinating rice research in IRRI, CIAT, IITA and WARDA. All four Centres are linked through the International Rice Testing Programme and other channels, and IRRI has posted rice liaison officers to the other Centres to ensure coordination. But whereas in Asia IRRI works directly with national systems, elsewhere it currently works through the liaison officers and the other Centres. IRRI cannot, in this way, mount major programmes in Africa or Latin America, although some countries wish them to do so. Our understanding is that IRRI is certainly willing to initiate substantial regional programmes in both these continents, or to work directly with national systems there, but would do so only if CIAT, IITA and WARDA agree, and if substantial additional resources are provided. Whether these should be partly core funds would depend on the size and nature of the regional programmes. TAC intends to take the initiative in convening a discussion of the principles and problems involved in allowing IRRI a more direct and significant role in Africa and Latin America.

UPLAND RICE

13. The Quinquennial Review Panel, TAC and IRRI are all agreed that the Institute was right in concentrating much of its early attention on irrigated and lowland rice, and all are agreed that it must continue to
do so. Nevertheless, IRRI has, over the years, also done a great deal of research on upland rice in the Asian region. The Quinquennial Review urges that this should now receive more attention (paras 347-), and this will certainly be needed if IRRI is to deploy regional projects in Latin America and Africa. However, there is a vast range of conditions and problems of upland rice, and accompanying confusion about its terminology and about what kinds of research are most needed. Research on rainfed, unirrigated upland rice - the category which has received least attention - is likely to be highly location-specific, much more so than for irrigated rice. Progress will be difficult, but TAC recognizes the need for such progress, however slow, as does IRRI.

FARMING SYSTEMS

14. The Quinquennial Review suggested that besides the substantial amount of research on cropping systems, IRRI should also facilitate collaboration with national systems on farming systems research (paras 314, 535). IRRI's Board and Director-General recognize the significance of these problems, but consider that to stretch the Institute's activities so much more widely would endanger one of IRRI's greatest strengths, that of concentration of effort. TAC concurs with this view and therefore supports IRRI in seeking a collaborative arrangement with UPLB and other bodies to explore the potentialities of such research in Asia.

LONG-TERM PLAN AND OTHER RECOMMENDATIONS

15. IRRI revised its long-term plan in preparation for the Quinquennial Review, and the review team made considerable use of and reference to this plan in its report. TAC considers the plan to be a most thoughtful and constructive one, and notes that IRRI proposes to revise its plan in the light of the Quinquennial Review report and of the discussions of it during the 28th TAC meeting. TAC welcomes this procedure, and will give detailed consideration to both technical and financial implications of the revised plan.

16. TAC believes that the main issues requiring discussion by the Group have been outlined above, and would appreciate an indication of the Group's views on each of them.
COMMENTS OF THE IRRI BOARD OF TRUSTEES
ON THE REPORT OF THE SECOND
TAC QUINQUENNIAL REVIEW OF IRRI

The Executive Summary

The report and IRRI's impact

1. The Board welcomes the report of the Second Quinquennial Review Team, which it believes will be of great value to the Institute in the further development of its research thrusts and priorities.

   It expresses its sincere thanks to the Chairman and Members of the Team for the exemplary way in which they have conducted their responsibilities.

Mandate

2. Careful consideration is being given by the Board to the changes in the mandate of IRRI which are needed to bring it more into line with present realities, so that it reflects the increasingly close collaboration with national research programmes, its role in germplasm maintenance, and attention to applied as well as basic research.

Involvement outside Asia

Further, the Board recognizes that IRRI should provide global leadership in rice research. Although its primary concern is with Asia where 90% of the world's rice is grown, its current programmes include activities in Africa and Latin America. It has liaison scientists in each of these continents, and the International Rice Testing Programme coordinated by IRRI operates in 75 countries. The mandate will be modified to reflect this world-wide involvement.

Policy regarding rainfed and irrigated rice

3. The Board recognizes that the most important challenge now facing IRRI is to develop improved rices for areas where water supplies are uncontrolled, resulting in either frequent drought or floods. However, it emphasizes
4. The Board welcomes the general approval of the research strategy outlined in the Plan for IRRI's Third Decade. The document submitted to the Team will be revised taking into account the views expressed in the report as well as by TAC. It agrees that a close relationship with fundamental research is essential for the continued success of the programmes of IRRI.

5. The Board believes that IRRI's activities in Africa and Latin America should continue to be conducted largely under the Memoranda of Agreement it has with CIAT, IITA and WARDA. The Board will await the results of the discussions to be initiated by TAC regarding the principles and problems involved in allowing IRRI a more direct and significant role in Africa and Latin America.

6. The Board strongly supports the Review Team's statement that IRRI has definite comparative advantages and a very strong staff, and, therefore, should be given special support.

7. The Board accepts the Recommendations and Suggestions for intensification of research in plant breeding for diverse growing conditions as well as in other areas, but reiterates the need for additional funds for implementing them. It also believes that there may be some detailed points raised such as inter-se priorities in research on diseases which require rather careful review before
implementation in the light of changing needs and circumstances.

Research programmes 8. With the reservations mentioned above the Board accepts the conclusions of the Team. It concurs with the view that the Cropping Systems activities should evolve towards Farming Systems, and agrees that this must be done through establishing appropriate linkages with national and regional research organizations.

Upland rice 9. The Board appreciates the relatively greater importance of upland rice research for Africa and Latin America, and recognizes that IRRI must give greater attention to upland rice as well as other rainfed rice production systems. It agrees that IRRI should provide leadership in upland rice research, and that it should do this by and large under the existing memoranda of agreement with CIAT, IITA, WARDA and TRAT.

International cooperation 10. The Board strongly supports IRRI's collaborative country programmes, and welcomes the recommendations to strengthen and extend these programmes. It favours the idea of offering tenure to outreach staff, but also recognizes the financial implications of such a change.

Training (added - Board did not discuss - have assumed would like addition of a comment on training) 11. The Board concurs with the Team's comments on the need for extension of the training programmes, to allow for the growing needs of African and Latin American countries, but is aware of the funding implications of further growth in the training programmes.

Facilities 12. The Board agrees with the Team's recommendations that the adequacy of existing screenhouse facilities needs to be reviewed, and
renovation and repair work initiated. It also agrees that a computer and electron microscope should be acquired (a computer IBM 4331 has since been donated to IRRI by the IBM Company).

Research programme organization

13. The Board concurs with the view of the Team that IRRI should explore the possibility of bringing together several existing activities within an Environmental Evaluation and Utilization Programme, but feels this must be done as part of a wider review of research programme structure.

Staff additions

14. The Board agrees that a real need exists to strengthen IRRI's staff in the areas identified by the Team. However, it would like to draw the attention of the CGIAR to the fact that substantial additional resources must be made available to IRRI if this work is to be undertaken. Even if special project funding is found for some activities supported from core, additional housing and other facilities will be needed for the additional staff.

September 1982
Dear Prof. Camus,

Enclosed I am sending to you the final draft of the "IRRI Second Quinquennial Review Report". In the Panel's judgment it follows the Terms of Reference and addresses the specific questions referred to the Panel by TAC, as guidelines. The findings, suggestions and recommendations were unanimously agreed upon.

All members of the Panel were pleased and honoured in servicing TAC and we hope the Report will be useful to TAC, IRRI, to the donors and to the CGIAR system as a whole.

Because it was not in the "Terms of Reference", the Institute was not reviewed in relation to the System. Nevertheless I personally think that the implementation of some important recommendations referring to global leadership in rice research and the role of regional Centres, to the involvement of a commodity centre in farming system, to the recognition of responsibilities towards regions outside Asia, will be more effective if guided by more global policies and better definition of the responsibilities of IRRI and the regional IARCs working on rice.

While recognizing the present financial difficulties concerning the CGIAR, the Panel made recommendations which - in order to implement them - will require additional financial support to IRRI. The Panel did so because in its consideration of the needs and potentials for the next five year ahead, it was not required to think in terms of "zero growth" or reductions in the programme. Also, because we believe there is no case for pessimism; the present difficulties are temporary and the intelligent people who created and implemented the System so far will be able to find new alternatives and develop the means to keep the System in its original track of necessary research for development and production, so important and so much needed by the poor and hungry people in the world.

/...

Prof. G. Camus  
Chairman of TAC  
c/o World Bank  
66 avenue d'Iéna  
Paris (France)
I want to take advantage of this opportunity to express my gratitude to IRRI's Board of Trustees, Directorate and staff, to the TAC Secretariat for the support in the preparation and development of the review, to the Panel members for the comprehension, dedication and hard work and to TAC for the opportunity to serve again the CGIAR.

Sincerely yours,

A. Blumenschein
THE CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH
TECHNICAL ADVISORY COMMITTEE

REPORT OF
THE SECOND TAC QUINQUENNIAL REVIEW
OF THE
INTERNATIONAL RICE RESEARCH INSTITUTE
(IRRI)

Panel: A. Blumenschein (Chairman)
K. Hemmi
P.J. Mahler
Y. Murata
I.N. Oka
W.H. Patrick
S. Singh
H. Will
J.C. Zadoks
D. Plucknett (Ex-Officio)
L.H.J. Ochtman (Secretary)

TAC SECRETARIAT
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
August 1982
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EXECUTIVE SUMMARY

1. The Quinquennial Review

The Panel was guided by TAC's general instructions for quinquennial reviews, a list of specific questions to be addressed, the first Quinquennial Review Report, and—of course—by the personal knowledge of the Panel members.

2. The Report

2.1 The purpose of this report is to enable IRRI to better carry out its mandate and to provide the CGIAR with information that will allow them to properly assess the programme.

2.2 The Panel's suggestions and recommendations were unanimously agreed upon. The report has gone into many details but, admittedly, does not cover all areas. The Panel did not deal with details of administrative and managerial affairs.

2.3 Where necessary, the Panel completes the discussion of a subject with RECOMMENDATIONS and/or SUGGESTIONS. The difference is in the priority. The Panel believes that the recommendations made, should be implemented unless serious objections appear, while suggestions are only offered for consideration. The recommendations have been listed separately.

2.4 The report ends with a chapter "General assessment and IRRI's third decade". In this chapter the Panel offers its views on IRRI's future. Based on the 5-years' backward view, its principal duty, the Panel offers a forward view.

3. IRRI's Impact

3.1 IRRI has had a great impact on rice production in many different ways. There are various yardsticks by which this can be measured.

(i) The advancement of science has been considerable with respect to rice genetics, rice physiology, rice soil science, and other fields of science. It is measured in the impressive series of publications and their widespread distribution and use.

(ii) Rice production in several Asian countries has been significantly improved as a result of the new technology. The Philippines have become a net rice exporter. South Korea is on the verge of self-sufficiency. Indonesia will reach self-sufficiency in rice within a few years. In many countries there were impediments to rapid advances, but the countries mentioned have been among the first to strengthen their own rice research capability.

(iii) In economic terms investments in IRRI of about 20 million dollars per year generate an added value of about 1.5
billion dollars per year of increased rice production. This fact indicates that this investment in rice research was appropriate.

(iv) The social impact of IRRI is difficult to measure; the following points have been noticeable in some countries at least:
- small farmers are now using high-yielding varieties
- reduction of off-farm employment
- increase in hired labour on farms
- increase in job opportunity in the villages
- reduction of drudgery
- improvement of living conditions (housing, health, education)

(v) Training. IRRI is one of the largest international agricultural training institutions with a large number of individuals from many countries participating in a wide range of training programmes.

(vi) National programmes. IRRI has strengthened national programmes by training and consulting, and by gradually proceeding from cooperative to collaborative projects.

3.2 These results would not have been obtained without the active participation of collaborating countries. Initiative is gradually shifting from IRRI to authorities in collaborating countries, a very positive change.

4. IRRI's Mandate

The increase in the complexity of functions required from IRRI, as well as the increase in national research capabilities, ask for a re-interpretation of IRRI's mandate. The present mandate of IRRI, which has served well for 20 years, definitely permits the updating of its interpretation to recognize the dual function of fundamental and applied research, to work on non-irrigated rice, to provide scientific back-stopping to national research institutions, to coordinate rice-based farming systems research in Asia, and to more fully recognize responsibilities towards regions other than Asia.

5. IRRI's Policy

From a distant viewpoint, IRRI's policy has been clear. The initial research investments were made to raise production of irrigated rice, and quite rightly so, because there the invested funds gave high and fast returns. A higher production level was attained with the new varieties and then stabilised with additional varietal improvement. Additional lines of research have emerged, such as better utilisation of available water (a programme that has become operational and is in good demand by collaborating countries) and the study of constraints in
production and of the adoption of new technology. The latter studies have not yet led to wide-scale applications. For two reasons a change of emphasis is needed: (i) the area and/or the funds available for new large-scale irrigated rice projects are becoming a limiting factor; (ii) very large populations live in areas which are not well suited for irrigated rice cultivation. Considerations of equity require more attention for these populations. The research emphasis has to shift to non-irrigated rice cultivation of various types, accepting the fact that the return on research investment will be slow and small in comparison to irrigated rice cultivation. The new research required is primarily in the areas of breeding, crop protection, physiology, and agronomy. The detailed recommendations reflect this change in emphasis, which - in the long run - may lead to a breakthrough in food production in underprivileged areas.

6. Suggested Changes

IRRI has anticipated changes in its role for the future, and has discussed these in its "A Plan for IRRI's Third Decade - A Proposal for Discussion with the Quinquennial Review Team". IRRI has already broadened its range of interests and has begun to re-examine many aspects of non-irrigated rice cultivation. The Panel's recommendations, therefore, are not revolutionary suggestions for change. One important suggestion is to re-emphasize fundamental research. Only by a balance between fundamental and applied research can a new plateau of rice production be obtained.

7. IRRI in the CGIAR System

7.1 The Panel had no authority to study IRRI in the context of the total CGIAR system. Technical relationships with IITA, WARDA and CIAT have been considered, and they were found to be not fully satisfactory. The Panel strongly suggests that IRRI be charged with global leadership in rice research. Also, to answer demands from national programmes, IRRI will have to coordinate research on rice-based farming systems in Asia, without becoming directly involved in the non-rice components.

7.2 The Panel trusts that the donors will recognize the obvious contributions to rice production made by IRRI since its establishment and will provide adequate support to enable this outstanding research institution to make even greater contributions to food production in developing countries.
LIST OF RECOMMENDATIONS AND SUGGESTIONS

The recommendations and suggestions are presented here in an order related to the consecutive chapters of the draft report and not in any particular order of priority. The Panel’s most important recommendations are marked by asterisks (***)

II. IRRI AS A RICE BREEDING, RESEARCH AND TRAINING ORGANIZATION

(d) The Mandate, its Appropriateness and Interpretation

(Para. 23). The Panel fully recognizes that IRRI’s current programmes and balance of efforts match the original objectives. However, being a well established Centre, covering a period of 20 years of operations, while planning for the third decade, the Panel recommends that IRRI update the interpretation of its mandate, taking into account present day realities, and in projecting for the future, sharpens the focus of its objectives and broadens its relationship with potential cooperators and collaborating developing national programmes.

(Para. 29). Taking into account that IRRI has already won wide trust and acceptance in Asian countries, the Panel considers it appropriate that IRRI’s research on rice cultivation be broadened, not only to include rice-based cropping systems, but to encompass also relevant aspects of rice-based farming systems. However, the Panel strongly recommends that emphasis on rice production be maintained and that IRRI seeks the cooperation and assistance from international, regional and national institutions in and outside Asia in solving the problems related to livestock production and to production of crops other than rice.

III. THE RESEARCH PROGRAMME THRUSTS

(a) Genetic Evaluation and Utilization (GEU)

(Para. 58). In view of the acute problems of pests and diseases on the IRRI farm, the Panel recommends that facilities for multiplication of accessions be provided away from the IRRI campus to the Germplasm Bank, and that some technicians be added to the staff to cope with this urgent work.

(Para. 59). Considering the amount of work involved in conserving, maintaining and evaluating the substantial germplasm collection, the Panel recommends that IRRI takes full advantage of the knowledge and experience of the leader in charge of the bank by giving him every opportunity and adequate means to devote all of his time to this unique activity.

(Para. 62). The compilation of permanent records on the genetic ancestry of rice varieties evolved in national programmes and put on computer files, has slowed down. The Panel recommends that the work be speeded up and made a part of permanent record keeping of the genetic ancestry of all past, present and future varieties of rice in all rice
The genetic survey should be an integral part of the activities of the Germplasm Bank.

There is a need for IRRI to develop varieties for less favourable, rainfed conditions in close collaboration with national research stations located in such areas. The Panel recognizes the importance of cooperative research among plant breeders, but recommends that individual responsibility be assigned for breeding work for the following conditions: (i) irrigated and rainfed, favourable, (ii) rainfed, shallow, (iii) rainfed dryland, (iv) rainfed, medium deep, waterlogged, (v) deepwater and floating.

IRRI's breeding work has reached a stage that new techniques, such as embryo culture, anther culture and somatic cell culture may be explored. The Panel recommends that a scientist should be hired for this work. Such a scientist should have experience in tissue culture work and a good background in plant breeding.

The Panel suggests that IRRI carefully reconsiders the numbers and sizes of the IRRI nurseries as well as the type of entries to be tested, in view of the workload and costs for both IRRI and those who plant and tend the nurseries. Furthermore, the Panel suggests that IRRI be linked more closely with the breeding programme.

(b) Control and Management of Pests and Diseases

In view of the genetic vulnerability of the modern rice crops, where millions of hectares are covered by a single genotype, the Panel suggests the development of specific measures to reduce the vulnerability by increasing genetic diversity and by gene deployment strategies, and to keep the situation under scrutiny by intensive monitoring.

The first Quinquennial Review identified the possible need of a rice nematologist; this was kept under review by IRRI, a decision so far justified by the facts. The Panel suggests that IRRI acquire nematological expertise, when needed, on an ad-hoc basis. The first Quinquennial Review also recommended that the testing of pesticides be reduced to the minimum level compatible with the identification of potentially useful compounds. The Panel reiterates the recommendation of the first Quinquennial Review Panel and it suggests the utmost reservation in the acceptance of coded compounds.

The Panel suggests that continued attention be given to resistance against tungro and its eventual strains, as distinct from resistance to its vector, the green leaf-hopper. Special methods to distinguish the two forms should be elaborated.

The Panel recommends "sequential release" of resistance genes as the standard strategy, and "gene deployment" and "pyramiding" as possible alternatives when new races or strains of a pathogen appear. The Panel suggests that continued efforts be made to find and utilize forms of "stable", "horizontal" or "slow diseaseing" resistances, preferably in combination with vertical resistance, especially for rice blast and sheath blight.
(Para. 130). Several diseases are seed transmitted and IRRI must avoid bringing a new disease into a country by IRRI seed transfers. The Panel suggests that the possibility of stationing a Bureau of Plant Industry seed pathologist at IRRI be pursued, even at some expense to IRRI. The Panel also suggests that procedures in handling incoming and outgoing seeds be rigorously defined and adhered to.

(Para. 133). The Panel suggests ranking the research priorities in plant pathology in the following order: (i) Rice blast research (all aspects). (ii) Tungro research. (iii) Economic thresholds and cost effectiveness of fungicides. (iv) Disease monitoring. (v) Maintenance research. (vi) Biological control.

(Para. 134). The Panel recommends that at least one Senior Plant Pathologist be assigned to rice blast research and that a task force of internal and external advisors be formed in order to approach the rice blast problem in an innovative way.

(Para. 146). The Panel recommends that the vacancy for a Senior Plant Breeder be filled to maintain the thrust of the "Insect Resistance" programme.

(Paras. 148 & 149). The Panel suggests the continuation of basic work in taxonomy, ecology, behaviour, and population dynamics at maintenance level, and that insecticide testing be limited as to the numbers of chemicals tested, that coded chemicals normally not be considered, and that emphasis be placed on application methods, especially root zone application and ultra-low-volume foliar application.

(Para. 150). The Panel suggests that the results of the comprehensive studies on brown planthopper be translated into practical methods of monitoring, forecasting, and integrated control, and -- after due testing -- channelled into an international network. This being achieved the Panel recommends that resources be redirected as indicated above.

(Para. 151). The Panel suggests that the idea of an international network in Insect Pest Management be explored and to establish this network if agreeable to national programmes.

(Para. 152). The Panel recommends the widening of the Insect Pest Management concept to an Integrated Pest and Disease Management concept, involving the cooperation of, among others, plant pathologists and weed scientists. To do so effectively will probably require a concerted effort for the whole of IRRI's third decade.

(Para. 153). The Panel suggests the continuation of the IRRI/ICIPE cooperation through the stationing of an ICIPE core-scientist at IRRI.

(Para. 154). The Panel suggests the following order of priorities in entomology research: (i) Insect resistance in all its aspects. (ii) Development of complete insect pest management packages including monitoring, population dynamics, economic thresholds and control with the brown planthopper as main target for the time being. (iii) Integration of these packages with disease and weed control into Integrated Pest and Disease Management systems according to rice cultivation types. (iv) Research
on the application of pesticides and on safety precautions, rather than continued testing of compounds. (v) Maintenance research over a broad area, at a fair level of intensity.

(Para. 155). The Panel recommends maintenance of the core-manpower in entomology at the present level.

(c) Irrigation Water Management

(Para. 182). One of the major problems in the development of a large scale irrigation system is the flooding of large areas of the lower lying parts of the irrigation basin during irrigation. Some areas where formerly one good crop of rice could be grown during the wet season are now so wet from wet season irrigation water flooding that only a dry season crop can be grown. In addition, many less severe drainage conditions disrupt planting and harvesting operations and adversely affect yields. The programme proposes to address the problem of drainage and the Panel recommends that as much research input as IRRI can afford be given to it.

(Para. 183). The Panel recommends that this important programme should be continued at approximately the same level of effort.

(d) Soil and Crop Management

(Para. 214). The Panel recommends that the programme on Soil and Crop Management be maintained at approximately the same level in Soil Chemistry, Agronomy and Soil Microbiology and that a high priority be given to the establishment of an effective soil physics programme. With the request to IRRI for work with rice cropping systems other than irrigated rice, consideration should be given to soils research that deals with problems of rainfed rice and upland rice.

(e) Environment and its Influence

(Para. 226). To have a consistent measure of rice lands and their characteristics, and to provide a basis for delineation and description of potential target areas, some classification of rice land must be adopted. Such a classification should be based on a synthesis of the three dominant physical factors, temperature, soil conditions, and water conditions. No existing data classify the world's rice lands by these three criteria. The Panel suggests that this work should be approached in a comprehensive coordinated way. IRRI might wish to consider ways in which environmental characterization, classification and perhaps management could be linked in a multidisciplinary way such as in the GEU programme.

(Para. 254). To define the tolerance of rice plants to various problem soils and to develop screening methods, the Panel recommends an increased emphasis on basic research in the physiological and genetic aspects of tolerance to problem soils. Collaboration with national programmes should be encouraged.

(f) Production Constraints and Consequences of New Technology

(Para. 286). The future plans of constraints research follow the lines of the development in the past. Moreover, these plans reflect
a re-direction of research activities from irrigated rice to rainfed rice. If these plans are realized they will not only greatly enrich our knowledge of constraints but also the methodology will be developed further. The Panel recommends that these plans be carried out.

(Para. 287). The first three of the plans for the future (i) - (iii) are important and feasible for reasons given above. In the field of consequences research, the Panel does not think that IRRI has a comparative advantage to study the development experience of such countries as Japan, Taiwan and Korea, and of Europe, Australia and North America; this may be left to economists in these countries. Although it has no doubt that additional sociologists or anthropologists could strengthen IRRI's activities, the Panel suggests, that if funds are available, agricultural economists from South or Southeast Asian countries should be invited to IRRI for additional training to strengthen national research capabilities in these fields. The Panel recommends that the monitoring and analysis of the changing rice economy in the Philippines, the village economy accounts and the rice policy project in Southeast Asia be continued.

(g) Cropping Systems

(Para. 310). The Panel supports the integrated approach followed in the analysis of physical and biological environment and suggests that similar methods be used at a smaller scale to develop synoptic inventories of the main rice lands of Asia by enlisting the cooperation of the national programmes concerned and of postdoctoral fellows and consultants from institutions familiar with those methodologies.

(Para. 314). The Panel notes that in all countries where IRRI has introduced the rice-based cropping systems activities, the ultimate ambition of governments is to develop farming systems, and considerable pressure is being brought to bear on IRRI by certain governments to move in this direction. The Panel further notes the limitation imposed by the IRRI mandate but recognizes IRRI's important link with national programmes in the area and its proven ability to deal with these problems. The Panel also notes the geographical location of IRRI relative to the other IARCs which have mandates for dealing with this problem and recommends that IRRI facilitate the cooperation of competent national and international institutions in bringing expertise to those elements of the farming systems programmes that are not covered by IRRI.

(h) Machinery Development and Testing

(Para. 335). The Panel recommends that grain dryers be given high priority by the core staff, since double cropping often results in high-moisture rice during the height of the rainy season. Effective, less expensive dryers are needed that can be fueled by local materials.
IV. IRRI AND UPLAND RICE RESEARCH

(Para. 350). The Panel gives particular importance to further progress at IRRI in the field of upland rice research and recommends that if the position of upland rice research leader rather than coordinator cannot be found by appropriate shifts within the existing staffing authorization, additional funds be sought to establish the required position. It is obvious that, when establishing this special position of senior scientist on upland rice, supporting staff, services and facilities will also be required including those of collaborative networks such as IRTP.

(Para. 351). The Panel recommends that the international meeting to be held at Bouake (Ivory Coast) on upland rice research devote particular attention to the development of the programme mentioned in the preceding paragraphs. The Panel also suggests that this meeting be attended by potential donors and administrators who may assist in the speedy implementation of this important undertaking.

V. INTERNATIONAL COOPERATION, TRAINING AND CONFERENCES

(a) International Cooperation

*** (Para. 387). The Panel supports IRRI's off-campus activity and strategy for Asia. To strengthen this, the Panel recommends:

a) To continue and improve relationships with developing countries through more intensive consultation.

b) To extend the recently developed annual programmes with the developing countries.

c) To increase cooperative work with developing countries which have specific rice cultural environments.

d) To promote the cooperation among developing countries in the field of common interest.

e) To strengthen the collaboration between IRRI and other IARCs.

*** (Para. 388). For cooperation with national programmes from developing countries outside Asia the Panel reiterates the recommendation made elsewhere in the report that IRRI updates the interpretation of its mandate in relation to its responsibilities to these areas. The Panel also strongly recommends that the agreements with other IARCs (CIAT, WARDA and IITA) be more effectively implemented.
(b) \textit{Training and Conferences}

(Para. 425). To maximize the impact of the Training Programmes and of the research output, the Panel \textbf{recommends} that:

(i) The time allocated by research staff and research assistants to teaching should not jeopardize the research performance.

(ii) Research scientists from developing countries should be posted at IRRI for a certain period of time (6-12 months or more) to expose them to new ideas and to give them an opportunity to carry out research of a more basic nature relevant to the research programme in their home country; not only Ph.D.'s should be considered but also those having M.Sc. degrees.

(iii) Other leading national universities should be considered to participate in the degree training programmes. At present IRRI collaborates with UPLB and Cornell University for degree training. The increasing enrolment at UPLB limits admission of foreign students to the University.

(iv) More attention should be given to Latin American and African countries in IRRI's training programmes with appropriate arrangements to take into account the language and other difficulties.

(v) In view of the fact that qualified agricultural economists are very scarce in Asia, a degree training programme (Ph.D.) in agricultural economics related to rice should be facilitated by IRRI.

(vi) Symposia, conferences and workshops should be organized as frequently and covering as wide a variety of topics as in the past few years. However, some additional gatherings to deal with unforeseen problems, should be allowed for.

\textbf{VI. SUPPORT PROGRAMMES AND FACILITIES}

(a) \textit{Library and Documentation Centre}

(Para. 434). The Panel suggests that the possibilities of modern efficient storage systems be explored before the library becomes congested, so as to avoid future requests for additional building.

(Para. 435). The Panel \textbf{recommends} that consideration be given to the protection of unique holdings such as departmental records and rare publications against fire and other dangers by copying them on micro-fiches and storing these copies elsewhere.

(Para. 436). Because of the possibility of obtaining a better penetration of IRRI publications in regions not using English as a vehicle
of scientific interchange, the Panel suggests the establishment of an abstracting service producing abstracts from IRRI publications in various languages.

(e) Computer Facilities

(Para. 466). The Panel suggests to increase the awareness of the IRRI scientists with respect to computer utilization and future users' needs. The Panel recommends that IRRI acquire adequate computer capacity, by donation or otherwise, after due inventory of future requirements of scientists, library, information services, and administration.

(f) Equipment

(Para. 472). The Panel suggests timely preparations begin for the replacement of the artificially lighted reach-in plant growth cabinets of the phytotron as these are approaching the end of their expected lifespan; replacement can be staggered.

(Para. 475). The Panel recommends that IRRI assign a high priority to the acquisition of a transmission electron microscope and ancillary equipment.

VII. MANAGEMENT AND ADMINISTRATION

(b) Administrative Organization

(Para. 489). The programme and budget document should also give information on the implementation of the long term plan and on its adjustment in the light of accomplishments and new problems.

(c) Administration and Personnel

(Para. 494). The Panel recommends that the Board and the Directorate of IRRI give immediate attention to the problems of professional development, tenure and career of off-campus staff.

(Para. 496). IRRI should strive to maintain the international composition of its senior staff.

VIII. GENERAL ASSESSMENT AND IRRI'S THIRD DECADE

(a) Preliminary Remarks

(Para. 507). IRRI's rationale for selected incremental additions in staff is given on a case-by-case basis and therefore difficult to relate to the much broader perspective of its plans for the future. The Panel recommends however that IRRI provides a broader analysis of the past and present resource use as a basis for a more comprehensive presentation of its future needs.
(c) The Changing Roles of IRRI in the Context of National Programmes Development

*** (Para. 531). The Panel recommends that the interpretation of the mandate of IRRI should be updated to reflect (i) its dual role in basic and applied research, (ii) its supportive role and servicing functions in the development of national rice research programmes and in the promotion of their cooperation, (iii) its involvement in rice-based cropping system research with a further broadening of its approach by contributing relevant rice technological components to farming system research development, (iv) its responsibilities in the maintenance and use of the world rice germplasm bank, and (v) the recognition of its responsibilities towards geographical regions outside Asia.

*** (Para. 532). The Panel strongly supports IRRI's proposal as regards its relationships to national and other international research efforts as outlined in its long term plan. The Panel recommends that the concepts presented by IRRI for its cooperation with other countries and institutions should constitute the backbone of its overall strategy in the implementation of its mandate, namely (i) the development of formal relationships and joint research planning; (ii) collaborative research, (iii) research networks, (iv) the provision of specialized supporting services to national rice programmes, (v) the training of rice researchers, (vi) the promotion of closer links between rice research, extension and production programmes at national level, and (vii) the promotion of communication activities, conferences, and workshops among rice research scientists.

*** (Para. 533). While agreeing with this strategy, the Panel strongly recommends that IRRI continue to decentralize at country level selected elements of its research and training activities in order to make fuller use of growing national capabilities. The Panel also recommends IRRI increase its efforts in promoting cooperation among national rice research programmes.

(Para. 534). The Panel recommends that in implementing these strategies, IRRI should assemble and utilize more information on the environmental and socio-economic conditions under which rice is grown in different countries so as to better define common problems, set priorities and develop a more integrated approach in the characterization of the main rice environments and target areas for research and technology transfer.

(Para. 535). The Panel recognizes that the development of rice production cannot be isolated at farm and village levels from other aspects of agriculture and therefore encourages IRRI in continuing research on rice-based cropping systems in cooperation with other countries. The Panel recommends that IRRI facilitate the collaboration of relevant institutions (national and international) in helping national programmes to tackle farming system research in a more integrated manner in the rice-producing regions.
(Para. 537). At the same time the Panel recommends that, resources permitting, a relative increase in emphasis be given to training and to selected aspects of dissemination of information in its core programme. The overall balance of activities of IRRI may, however, not be significantly affected, if in the meantime IRRI continues to enlist the cooperation of scientists in advanced research in the several areas recommended by the Panel through special projects and other cooperative arrangements.

*** (Para. 538). The Panel wishes to recommend that IRRI develops clearly identifiable and focussed programmes for each of the main categories of rice cultures. This will necessitate some changes in breeding procedures and some additional staff in breeding.

(Para. 539). The Panel did not find a major imbalance in the present pattern of resource allocation to the problem areas, programmes and disciplines but recommends certain staff additions and shifts which will be required in the gradual implementation of IRRI's strategy in the third decade. These changes should take place using the existing procedures involving the staff, the Directorate and the Board as well as IRRI's cooperators in the review and formulation of the programme procedures, which the Panel strongly supports. The changes should lead to an increase in the relative importance of breeding and some supportive basic research.

(Para. 540). The Panel recommends that IRRI examine the possibility of ensuring a similar integration of the disciplines as in GHI for such areas as environment analysis and assessment, soil-crop-water management and cropping systems within the limits of the presently available core resources for these activities and the assistance of non-core staff (visiting scientists, postdoctoral fellows, etc.). In doing so, the Institute should appoint programme leaders with clear responsibilities within the programme areas.

(Para. 541). Among the recommendations the Panel has made, some have a bearing on IRRI's future resource requirements and allocations. These recommendations are:

(i) The Department of Plant Breeding needs strengthening in view of the strategies and priorities indicated for GHI in Chapter III and in IRRI's plan for its third decade. Resources should be found to create the appropriate number of breeder-positions which would enable IRRI to give separate attention to five major categories of rice culture, to hybrid rice and to other innovative breeding techniques and related physiological aspects.

(ii) The established positions for the head of the Plant Pathology Department and a senior plant pathologist should be filled as soon as possible.

(iii) The INSFER Coordinator should be part of the core staff.
(iv) The position of soil physicist recommended by the first Quinquennial Review should be established and filled.

(v) The editorial staffing of the information services department should be reassessed in order to enhance their training capacity and delivery in the context of the strategy of IRRI for its third decade.

(vi) Additional support staff and other means should be provided to the germplasm bank to fulfill its growing obligations.

(vii) An electron microscope and a suitable computer facility should be provided to IRRI as soon as possible.

(viii) Additional screenhouse facilities as recommended by the first Quinquennial Review should be provided so as to alleviate the pressure on the phytotron.

(ix) The Board and the Management should pursue their efforts in streamlining the procedures for administration and accounting and for the efficient use and maintenance of IRRI's resources and facilities.

(x) Consideration should be given to the possibilities of retaining off-campus staff during interim periods between their fixed term contracts, by a revolving fund or other appropriate means.

(Para. 542). The Panel realizes that the above recommendations call for a major increase in IRRI's resources. The Panel also notes that IRRI has been successful so far in attracting special project support, contracts, visiting scientists and postdoctoral fellows to fill some of its requirements. The Panel however wishes to stress that some of the above requirements are of a more continuing nature than others, especially those referred to under (i), (ii), (iii) and (iv) in order of priority and should therefore be part of the core programme of IRRI.

(Para. 543). Several programmes are relatively well staffed. Some of these should be considered for a relatively larger proportion of special project support to alleviate pressure on the core budget that will result from the above recommendations. The quality of and the interest shown in IRRI's activities in machinery development and some aspects of its economic work and irrigation water management could attract special project support.

*** (Paras. 544 & 545). IRRI is an outstanding research institution with a proven record of accomplishments and its results have had a significant impact on rice production, particularly in Asia. IRRI's basic strength could be further weakened if it is asked to take on other responsibilities without additional support and at the expense of existing programmes. The Panel would not favour such an approach, and would suggest that the donors and scientific research institutions consider special support to IRRI as recognition of its strong staff and programme, and the impact of its work.
Chapter I INTRODUCTION

1. In this introductory chapter some basic information is given on the Consultative Group on International Agricultural Research and on the International Rice Research Institute. The second Quinquennial Review, its terms of reference, preparations, activities and its report are briefly discussed.

2. The Consultative Group on International Agricultural Research (CGIAR), founded in 1971, is an international consortium sponsored by the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the World Bank. It seeks to increase food production in the developing world through research programmes and training scientists and production specialists in these countries.

3. The Consultative Group is comprised of 35 donors, including 19 governments, 11 international organizations and development banks and five foundations, and ten non-donor developing nations as representatives of the five major developing regions of the world, Africa, the Middle East, Asia, Latin America, and Southeastern Europe, nominated by the FAO Regional Conferences on a two-year term basis.

4. The 13 institutions which the CGIAR supports are autonomous international research and training institutions with an international staff of scientists, supported by locally recruited technicians. Each is governed by its own international Board of Trustees.

5. The CGIAR has an independent Technical Advisory Committee (TAC) entrusted with the periodical assessment of the achievements, the appropriateness and the effectiveness of the programmes of the International Agricultural Research Centres. These reviews of individual centres are conducted by TAC at approximately five-year intervals. The first Quinquennial Review of the International Rice Research Institute (IRRI) took place in late 1975. At its Twenty-second meeting in July 1979 TAC agreed that the work of IRRI should be reviewed again, and ultimately the second Quinquennial Review was planned for January 1982.

6. IRRI was formally established on 14 April 1960 in Los Baños in the Philippines by the Rockefeller Foundation and the Ford Foundation in cooperation with the Government of the Philippines, as an educational and research centre for the study and improvement of rice in recognition of the need to match food production with the massive population increase in the tropics where rice is the primary staple food. It was felt that only an international rice research and training centre, free from the political and geographical constraints of national governments but attuned to the needs of these countries, could develop improved varieties and better technology for the low-income tropical rice farmer, through rice research in the tropics.

7. The present Quinquennial Review Panel is charged with the following responsibility, as laid down in the Terms of Reference for TAC Quinquennial
Reviews of the International Agricultural Research Centres:

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

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

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

(i) The mandate of the Centre, its appropriateness and the interpretation thereof with respect to:
   (a) the immediate and long-term needs for improved food supply and human welfare in developing countries;
   (b) present and possible future areas of work.

(ii) The relevance, scope and objectives of the present programme and budget of the Centre and of its forward plans for the next five years in relation to:
   (a) its mandate and the criteria for the allocation of resources as defined by TAG;
   (b) the ongoing activities of other international institutions and organizations, and of relevant national institutes in cooperating countries and in others where the work of the institutes has bearing;
   (c) the policy, strategy and procedures adopted by the Centre in carrying out its mandate, and the mechanisms for their formulation;
   (d) the Centre's rationale for its present allocation of resources, its present and future overall size, and the composition and balance of the programme in the fields of research, training, documentation, information exchange and related cooperative activities.

(iii) The content and quality of the scientific and related work of the Centre with particular reference to:
   (a) the results of past research;
   (b) the current and planned research and the role of the scientific disciplines therein;
   (c) the information exchange and training programmes, their methodologies, their specialization and decentralization, and the participation of the research staff therein;
   (d) the adequacy of the research support and other facilities;
(e) the management of the scientific and financial resources of the Centre and the coordination of its activities.

(iv) The impact and usefulness of the Centre's activities in relation to:
(a) the present and potential agricultural production of the relevant countries and regions;
(b) its information exchange and training programmes;
(c) cooperation with national research and development programmes;
(d) cooperation with other international institutes and organizations.

(v) Constraints on the Centre's activities which may be hindering the achievement of its objectives and the implementation of its programmes, and possible means of reducing or eliminating such constraints.

(vi) Any specific questions which concerned members of the CGIAR, cooperating institutions, the Centre's Director or its Board of Trustees, may request TAC to examine.

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

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

The Quinquennial Review Mission should also assess the impact of the preceding Quinquennial Review on the programmes and activities of the Centre.

Preparations

During 1980-81 TAC prepared in consultation with IRRI's Directorate, its Board of Trustees and CGIAR members a list of questions to be addressed by the Quinquennial Review Panel (appended in Annex I). In further consultations with IRRI's Board of Trustees and its Directorate details of the Review Programme and the composition of the Review Panel (Annex II) were discussed and agreed upon by TAC at its 26th meeting in June 1981. Furthermore, the Chairman designate, Dr. A. Blumenschein, then a Panel member, and the Secretary of the Panel were invited to attend a meeting of the Board of Trustees in October 1981 to discuss with the Board and the Directorate the scope of the Review, its programme and related matters.
9. Both the TAC Secretariat and IRRI provided the Review Panel with a comprehensive set of relevant briefing documents, detailed in Annex IV. In the documentation IRRI gave a detailed account of its response regarding each of the first Review's 91 recommendations and in the relevant chapters of this Report they will be dealt with more specifically when appropriate. According to their account, the recommendations of the first Quinquennial Review have in general been implemented by IRRI extensively and conscientiously and where they have not been complied with, either in part or in full, the Institute presented its rationale for this.

Activities

10. The Review Panel assembled in Jakarta on 3 January 1982 for a one week visit of collaborative and national programmes in Indonesia, which included the Research Institute for Food Crops (SURIF) at Sukamandi in West Java and the Transmigration Project in Lampung, South Sumatra. It also had an opportunity to discuss the work with associated national and IRRI staff, and with senior officials of the Indonesian Government, World Bank, USAID and FAO/UNDP. On 9 January the Panel travelled to IRRI's headquarters at Los Banos, Philippines, for its review of the Institute, where it had extensive discussions with IRRI's Directorate and staff, as well as with representatives of the Board of Trustees. The Review Programme included a visit of experiments and facilities at the station, a tour of Central Luzon and Panay Islands. Details of the Panel's programme, its itinerary and the persons consulted are given in Annex III.

The Report

11. On 23 January 1982 the Review Panel, through its Chairman, presented its collective findings and recommendations to the IRRI Directorate, the senior staff and representatives of the Board of Trustees, and provided them with the draft report for their comments.

12. The Review Panel accepts sole responsibility for this Report. It is structured in a manner so as to reflect the findings of the Review with reference to the following major areas:

- the importance of rice in world agriculture, IRRI's mandate, organization, mode of operation and funding (Ch. II);
- IRRI's research programmes, associated services and support programmes (Ch. III, V, VI);
- IRRI's governance, management and administration; (Ch. VII);
- an assessment of IRRI's impact on rice research and production during the last quinquennium and of its long term plans for

1/ "Summary of Organization and Plans for Future Activities; for discussion with the Quinquennial Review Team, January 1982", Chapter 3: "Recommendations of previous Review (1975) and responses by IRRI".
13. In reviewing IRRI's research thrusts particular attention was given to a discussion on upland rice, since "TAC had recommended that IRRI develop a clearly identifiable and integrated programme specifically focussed on upland rice and take the lead in developing a better type for upland rice." 2/ The Panel has consolidated its views on upland rice in Chapter IV.

1/ A Plan for IRRI's Third Decade, IRRI, January 1982.
14. Chapter II provides some elementary information on rice. The importance of rice as a world staple food is indicated, as is the variety of water regimes and physical environments under which rice is grown. This information is relevant to the discussion presented here of IRRI's mandate, its appropriateness and interpretation. IRRI's organization, programme structure, mode of operation and funding, developed to implement the mandates, are described in brief.

(a) Rice in World Agriculture and Nutrition

15. Rice supplies a larger proportion of the world's dietary energy than any other food. Of seven countries in the world which have a population of over 100 million, five are major rice consumers. Moreover, in developing countries the importance of rice in their agriculture and nutrition is evident. In 1975-79, of the average annual production of 382 million tons of cereals in 90 developing countries, which account for 98% of developing countries' population excluding China, 138 million tons was rice (i.e. milled rice which is 207 million tons in terms of paddy). This surpasses by far the second most important cereal, wheat. Rice is the major source of protein and calories for 1,500 million low-income people in Asia alone, and for hundreds of millions of low-income people in developing countries in Africa and Latin America. Rice occupies one third of the area planted to cereals in the developing world, which is about 50% more than wheat. More than 95% of the world's rice area is in the developing countries, mostly in Asia. Although development strategy should usually be directed at the level of national economies rather than at individual commodities, there is some justification for singling out the rice development strategy for the above reasons.

16. According to the FAO study Agriculture: Toward 2000, if past trends in demand and production continue, the annual gross import requirement of rice of the 90 developing countries would rise from 8.3 million tons of paddy in 1974-76 to 33 million tons in 2000, and their net import requirement from 3.3 to 7.6 million tons. As in the past, a steep rise in their imports of wheat and other cereals will continue, reflecting partly the scarcity of rice in these countries. Such massive imports would represent one of the most difficult development problems. Therefore, the principal objective of long-term strategy of rice development is greater self-sufficiency in rice. FAO proposed that during

Self-sufficiency should not be considered rigidly, since it is just as much a function of change in demand as in supply, either of which can be induced by economic changes outside the rice economy rather than economic and technical changes in the rice economy.
the quarter of a century between 1974-76 and the year 2000, rice production
in the 90 developing countries should more than double, rising by almost
200 million tons of paddy, i.e. 102%. Thus, the annual rate of increase
in rice production in the countries concerned should be from 2.4% during
the period of 1961/65 to 1974/76, to 2.8% for the period 1980 to 2000.
In view of the increasing shortage of new land that could easily be taken
under rice cultivation, the proposed strategy relies heavily on increasing
the productivity of the existing rice area either by raising yields and/
or cropping intensities more than in the past.

3) Rice Production under Different Water Regimes

17. Available estimates show that irrigated rice occurs in about half
of the world's harvested rice area, whereas rainfed lowland rice covers
about 35%, upland rice about 10%, and deep-water rice about 5% of the
rice growing area. Of the total irrigated area (harvested) more than
46% are partially irrigated. The repair, modernization or completion
of existing irrigation systems brings higher and quicker returns than the
construction of new ones. It is estimated that the costs of constructing
new fully irrigated systems is almost three times higher than the costs
of improving existing partially irrigated rice.

18. So far, attention has been far too exclusively concentrated on
irrigated rice. Moreover, it is likely to be more difficult to develop
improved technologies for rice under non-irrigated water regimes than
under irrigated regimes because of the great diversity of environmental
conditions resulting from the lack of water control. Problems of rainfed
rice are not only of low yield per hectare but also those of greater yield
instability which results in a greater risk for improved practices.

In many areas where improved technology is less feasible, in a greater risk for
irrigated rice, it is likely to be more difficult to develop
improved technologies for rice under non-irrigated water regimes than
under irrigated rice.

19. Some rice is grown at high elevations in the tropics and as winter
crop in the low-elevation sub-tropicals, whereas low temperatures
limiting factors. In addition, substantial areas in China, Korea, Japan,
Afghanistan and India encounter a combination of long days, short growing
seasons, and low temperatures. In some areas, short growing seasons
and low temperatures limit the production of rice grown at high elevations.
temperature effects. Some of the world's poorest people inhabit the low-temperature areas and subsist mostly on rice and other cereals.

20. Other areas are affected by high temperatures, such as parts of Northwestern India, Pakistan, Iran and the Middle East, and represent some 4% of Asia's rice area. In addition, some rice growing areas in Africa and Latin America have a high-temperature limitation.

Soil Problems

21. In South and Southeast Asia as much as 100 million ha of land otherwise suited to rice production are left uncultivated due to soil problems, such as salinity, alkalinity, strong acidity, or excess organic matter. There are also about 50 million ha of cultivated lands where deficiencies of zinc, phosphorus and iron, or excesses of iron and aluminium, limit rice yields. Similar problems occur in Africa and Latin America. The feasibility of increasing rice production with reasonable research and development inputs in areas where adverse soils are prevalent is certainly of considerable interest.

(d) The Mandate, its Appropriateness and Interpretation

22. When IRRI was formally established in 1960 by the Rockefeller and Ford Foundations, in collaboration with the Government of the Philippines, the following objectives were broadly stated:

"1. To conduct basic research on the rice plant, on all phases of rice production, management, distribution, and utilization with a view of attaining nutritive and economic advantage or benefit for the people of Asia and other major rice-growing areas through improvement in quality and quantity of rice;

2. to publish and disseminate research findings and recommendations of the Institute;

3. to distribute improved plant materials to regional and international research centres where they might be of significant value or use in breeding or improvement programmes;

4. to develop and educate promising young scientists, primarily from South and Southeast Asia, along lines connected with or relating to rice production, distribution and utilization, through a resident training programme under the guidance of well-trained and distinguished scientists;

5. to establish, maintain and operate an information centre and library which will provide, among others, for interested scientists and scholars everywhere, a collection of the world's literature on rice;

6. to organize or hold periodic conferences, forums and seminars, whether international, regional, local or otherwise, for the purpose of discussing current problems."
23. This broad approach was appropriate to provide the Institute wide latitude in developing its course. The Panel fully recognizes that IRRI's current programmes and balance of efforts match the original objectives. However, being a well established Centre, covering a period of 20 years of operations while planning for the third decade, the Panel recommends that IRRI update the interpretation of its mandate, taking into account present day realities, and in projecting for the future, sharpen the focus of its objectives and broaden its relationship with potential cooperators and collaborating developing national programmes.

24. The mandate prescribes that one of the objectives of the Institute is "To distribute improved plant materials to regional and international research centres ...". However, as already recognized by IRRI's staff, some national programmes have now developed sufficient strength to fully and appropriately use these materials in their own research and thus the mandate should be interpreted to include not only international and regional centres which qualify to receive such materials, but also individual national programmes.

25. As regards its geographical mandate, the Institute has concentrated most of its efforts in Asian countries. An analysis of the statistics of present day rice production and consumption in the world and its projections for the future support the appropriateness of this priority. Nevertheless, the increasing socio-economic needs of individual African and Latin American countries, where dryland types of rice cultivation prevail and modern technology in rice production is still lagging behind, justify now a more global emphasis on the interpretation of IRRI's mandate. Therefore, other parts of the world, especially Africa and Latin America, should increasingly benefit from IRRI's germplasm collection, improved materials, new technologies and technical backstopping in the development of their basic research. To this end, IRRI should assume global leadership in rice research and closely cooperate with national, regional and international institutions, including those outside Asia.

26. It has been mentioned in preceding paragraphs of this chapter that if past trends in demand and production of rice continue, the rice production will need to increase by over 2.8% per annum until the end of the century. In IRRI's view, this requirement has to be obtained largely as extra yield per hectare, or from extra crops grown per year, as new land available for rice production in Asia is limited. For areas with special production constraints, there is a shortage of funds to develop capital intensive irrigation systems in developing countries.

27. On the other hand, farmers producing rice in areas with special problems (mainly in upland conditions) are at a great economic disadvantage. The Institute has so far concentrated its efforts on irrigated rice in Asia, but the above considerations emphasize the increasing need for technology to grow rice in other environments.

28. Consequently, the Panel considers it appropriate for IRRI to allow a more flexible interpretation of its mandate to increase the focus
on types of rice cultures other than irrigated rice. The mandate clearly recognizes mission-oriented research, both basic and applied, as objectives; the Institute vigorously pursued these in relation to irrigated rice. The Panel suggests that a similar balance be struck in focussing on other types of rice.

29. IRRI is deeply involved in rice-based cropping systems research and the impact of its work in this area is widely recognized. As a natural consequence, national programmes are now expecting IRRI's involvement at the farming systems level. Taking into account that IRRI is a CGIAR Centre that has already won wide trust and acceptance in Asian countries, the Panel considers it appropriate that IRRI's research on rice cultivation be broadened, not only to include rice-based cropping systems, but to encompass also relevant aspects of rice-based farming systems. However, it strongly recommends that emphasis on rice production be maintained and that IRRI seeks the cooperation and assistance from international, regional and national institutions in and outside Asia in solving the problems related to livestock production and to production of crops other than rice. More detailed justification is presented elsewhere in this report.

30. IRRI recognized that insufficient priority has been given to areas involving "distribution and utilization" of rice. The justification is that several other specialized institutions are devoting some attention to these subjects. On the other hand, it has been found that the problems related to these areas, especially post-harvest losses are affected by several factors, each having a relatively small effect. To resolve the problems caused by each of these factors requires a great effort, while contributing only little to increase total rice production. Nevertheless, the farmers are clearly calling attention to their problems in these areas and the new concepts produced by the cropping systems studies are increasing the understanding of the significance of the problems. Closer attention should be given to the real dimension of the problems in these areas at village and at farm levels and to the need for additional efforts.

31. In pursuing the objectives of its mandate the Institute has so far struck a proper balance between conducting research and providing educational and scientific support, such as publishing, training, distributing improved materials, and organizing conferences, workshops and seminars. However, as the national programmes grow stronger and become better organized, it can be anticipated that requests for scientific support will increase; therefore, IRRT should prepare for such a shift in the balance of its activities on entering its third decade.

(e) Organization, Programme Structure, Mode of Operation and Funding
Organization and Approach

32. The Institute's main objectives are to attain nutritive and economic benefit for the people of Asia and other major rice-growing areas through
improvement in quality and quantity of rice and improvement in productivity of rice lands. Therefore, the research programmes are oriented to produce more rice per crop per hectare and to increase the cropping intensity, with a primary focus on the practical aspects of crop improvement, management and protection. IRRI scientists conduct research primarily at headquarters in Los Banos. In addition, they participate in various national programmes. The general validity of the scientific findings from special locations is tested internationally in various cooperative and collaborative research and testing schemes.

33. As any sustained increase in rice production in a country is primarily achieved through the efforts of a corps of highly qualified and dedicated national scientists, IRRI conducts several training programmes, including those leading to M.Sc. and Ph.D. degrees, to strengthen the capability of the research personnel in these countries.

34. Conventional rice varieties in the tropics and sub-tropics neither produced high yields, nor responded positively to all improved crop production practices because of their susceptibility to lodging due to tall height. To eliminate this tendency, IRRI developed a series of semidwarf varieties which respond favourably to improved agronomic practices owing to their lodging resistance. IR8, the first variety in this series, when grown under improved agronomic practices, produced yields at least double those of traditional varieties. As its acceptance and its cultivation expanded, the variety was severely damaged by pests and diseases in some areas. This and the fact that rice is grown under a wide variety of agro-economic conditions and physical and biological constraints, emphasized the need for concerted inter-disciplinary efforts toward varietal improvement and improved crop management practices. Therefore, since 1973 the Institute reorganized its activities into inter-disciplinary, problem oriented research areas and priorities, as shown in Table 1.

Table 1: IRRI's Interdisciplinary Research Areas and their Priorities 1/

<table>
<thead>
<tr>
<th>Research Areas</th>
<th>Overall Relative Emphasis (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetic Evaluation and Utilization (GEU)</td>
<td>40</td>
</tr>
<tr>
<td>Cropping Systems</td>
<td>20</td>
</tr>
<tr>
<td>Control and Management of Rice Pests</td>
<td>10</td>
</tr>
<tr>
<td>Soil and Crop Management</td>
<td>10</td>
</tr>
<tr>
<td>Machinery Development and Testing</td>
<td>7</td>
</tr>
<tr>
<td>Irrigation Water Management</td>
<td>5</td>
</tr>
<tr>
<td>Constraints on Rice Yields</td>
<td>3</td>
</tr>
<tr>
<td>Consequences of New Rice Technology</td>
<td>3</td>
</tr>
<tr>
<td>Climatic Environment and Rice</td>
<td>2</td>
</tr>
</tbody>
</table>

Research activities are administered through Departments; research is coordinated within nine interdisciplinary Research and Training Problem Areas. This structural approach allows flexibility in dealing with new problems. Within each Problem Area, Research Programmes are organized, again on an interdisciplinary basis. Those operating at present are shown in Table 2.

Table 2: The Structure of IRRI's Research

GENETIC EVALUATION AND UTILIZATION OF RICE
- Genetic resources
- Agronomic and related characteristics
- Grain quality
- Disease resistance
- Insect resistance
- Nutritional value
- Drought resistance
- Adverse soils tolerance
- Deep water and flood tolerance
- Adverse temperature tolerance
- Innovative breeding methods (RGA, Tissue culture)
- Genetic monitoring and data management
- International Rice Testing Programme

CONTROL AND MANAGEMENT OF RICE PESTS
- Control and management of rice diseases
- Control and management of insect pests of rice
- Control and management of weeds in rice paddies

IRRIGATION WATER MANAGEMENT
- Water use and crop production
- Water distribution and control
- Water management alternatives
- Social and economic issues in irrigation water distribution

SOIL AND CROP MANAGEMENT
- Soil characterization
- Management of soil and fertilizer nitrogen
- Nitrogen fixation for paddy rice
- Management of organic manures
- Management of other nutrients
- International Network on Soil Fertility and Fertilizer Evaluation for Rice
- Rice crop cultural practices
- Tillage and management of soil physical conditions

1/ The main headings represent the Research and Training Problem Areas (in capitals), and related Research Programmes are listed under these headings.
CLIMATIC ENVIRONMENT AND RICE

Characterizing the climatic environment for rice
Rice response to environment
Climate and rice production

CONSTRAINTS ON RICE YIELDS

Socio-economic constraints
Management constraints
Institutional and policy constraints

CONSEQUENCES OF NEW RICE TECHNOLOGY

Effects of new rice technology on social and economic conditions
Consequences of mechanization on social and economic conditions

CROPPING SYSTEMS

Analysis of the physical and biological environment
Analysis of the social and economic environment
Pest control in rice-based cropping systems
Design and evaluation of cropping systems
Selection and testing of cultivars for use in rice-based cropping systems
Agronomic management in rice-based cropping systems
Preproduction testing of improved cropping patterns
Asian Cropping Systems Network

MACHINERY DEVELOPMENT AND TESTING

Machinery design
Machinery evaluation
Industrial extension.

36. In addition to the Research Programmes, the Institute operates a number of interdisciplinary Research Teams which deal with specific problems of the different rice cultural types, as shown in Table 3.
Table 3: IRRI Research Programme by Rice Cultural Type and Their Target Areas

<table>
<thead>
<tr>
<th>Rice Cultural Type</th>
<th>Principal Target Areas</th>
</tr>
</thead>
</table>
| 1. (a) Irrigated  
  (i) Tropical  
  (ii) Subtropical | All major tropical rice areas  
  Korea, China, Nepal |
| (b) Favourable rainfed, shallow | Indonesia, Philippines,  
  Vietnam, Malaysia |
| 2. (a) Rainfed, shallow, drought prone | N & NE India, parts Indonesia,  
  tropical Africa & Latin America |
| (b) Rainfed, dryland | |
| 3. (a) Rainfed, shallow, drought & submergence prone | NE Thailand, Laos, Kampuchea |
| (b) Rainfed, shallow, submergence prone | S. Thailand, S. Indonesia,  
  Burma, Northern Philippines |
| 4. (a) Rainfed, medium deep, waterlogged | E. India, Bangladesh, Vietnam |
| (b) Rainfed, medium deep, tidal swamp | Indonesia, India, Burma |
| 5. (a) Deepwater | Bangladesh, Thailand, NE India,  
  Vietnam, Burma |
| (b) Floating rice | |

37. For technical and administrative purposes the Institute's organization is structured as follows:

- Office of the Director-General
- Outreach Staff
- Administrative and Professional Staff
- Agricultural Economics Department
- Agricultural Engineering Department
- Agronomy Department
- Chemistry Department
- Entomology Department
- Experimental Farm
- Information Services Department
- International Rice Testing Programme (IRTP)
- Irrigation and Water Management Department
- Library and Documentation Centre
- Multiple Cropping Department
- Phytotron
- Plant Breeding Department
- Plant Pathology Department
- Plant Physiology Department
- Rice Production Training and Research Department
- Soil Chemistry Department
- Soil Microbiology Department
- Statistics Department

Mode of Funding

38. The Institute submits to the CGIAR a biennial budget proposal which also includes forward projections for the subsequent biennium. The donor members of the Group provide funds on an annual basis for the Institute's core operations and for capital expenditure.

39. A member of the Consultative Group has the prerogative to support certain components of the Institute's core operations and capital requirements, and not others, resulting in a differentiation between unrestricted and restricted core funding.

40. The Institute's core operations budget consists of the following components:

- Research programmes
- Conferences and training
- Library, documentation and information services
- General administration
- General operating costs
- Other expenditure, such as medical services, contingency reserve, etc.

The elements of these components are personnel services, supplies, equipment, travel, maintenance, etc.

41. The core funded operations programme includes one core research project outside the host country with outposted core staff - the deepwater rice research programme in Thailand - and the regional liaison functions. Of the international research and testing networks only the International Rice Testing Programme (IRTP) is core funded, but it is a "restricted core" programme. Most donors contribute in the form of unrestricted core, only a few - Japan, UNDP, EEC and IFAD - contribute for particular reasons to selected programme components, i.e. restricted core programmes. Some donors contribute in both - unrestricted and restricted - manners.

42. Besides its core funded programme, IRRI jointly with several national programmes and with some donors is involved in a number of extra-core 'special projects'. These special projects are commonly cooperative country projects in which a national agency requests the Institute's assistance in rice research, financed by a donor. As the
national rice research programmes increase their strength and capability, usually a shift occurs from cooperative country projects to collaborative research projects aiming at finding solutions to problems of mutual interest, both to the national agency and IRRI.

43. Other kinds of special projects are the collaborative research projects with developed-country research institutions for specialized assistance to resolve particular research problems. Also the research and testing networks, with the exception of IRTP, are financed as special projects by interested donors.
Chapter III. THE RESEARCH PROGRAMME THRUSTS

44. Development of rice technology is one major duty of IRRI. This chapter elaborates on IRRI's nine problem areas for the development of rice technology. The discussion of each problem area and/or research programme is structured by using some of the following elements: Background and objectives; Main Achievements, Constraints; Priorities; Future Plans; Comments by the Panel; Recommendations. A synthesis of IRRI's programme is covered in Chapter VIII.

(a) Genetic Evaluation and Utilization (GEU)

45. The coordination of IRRI's rice improvement programme was organized in 1973 by formalizing an institute-wide Genetic Evaluation and Utilization (GEU) programme. This is now a major interdisciplinary effort whereby plant breeders are teamed up with scientists from other departments. This programme is also linked up with similar national and regional programmes in Asia, Africa and Latin America to jointly evaluate and develop improved rice varieties, as well as to identify elite breeding lines for the various types of rice growing areas of the world. This Problem Area which started with seven multidisciplinary teams has gradually expanded and at present comprises the following research programmes:

- Germplasm collection, conservation and dissemination
- Agronomic characteristics of rice crop
- Insect resistance
- Disease resistance
- Grain quality and nutrient content
- Drought resistance
- Adverse soils tolerance
- Deepwater and flood tolerance
- Temperature tolerance
- International rice testing
- Innovative breeding techniques
- Genetic monitoring and data management

46. Scientists from twelve disciplines participate in this research area and for illustrative purpose the Panel presents hereunder the input by senior scientists from each of the disciplines in terms of man years as provided by IRRI administration:
<table>
<thead>
<tr>
<th>Discipline</th>
<th>Scientific Time (man years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plant Breeding</td>
<td>5.48</td>
</tr>
<tr>
<td>2. Agronomy</td>
<td>1.60</td>
</tr>
<tr>
<td>3. Plant Pathology</td>
<td>1.60</td>
</tr>
<tr>
<td>4. Plant Physiology</td>
<td>1.60</td>
</tr>
<tr>
<td>5. Entomology</td>
<td>1.10</td>
</tr>
<tr>
<td>6. Chemistry</td>
<td>1.00</td>
</tr>
<tr>
<td>7. Soil Chemistry</td>
<td>0.80</td>
</tr>
<tr>
<td>8. Statistics</td>
<td>0.25</td>
</tr>
<tr>
<td>9. Agricultural Economics</td>
<td>0.15</td>
</tr>
<tr>
<td>10. Rice Production Training and Research</td>
<td>0.25</td>
</tr>
<tr>
<td>11. Experimental Farm</td>
<td>0.45</td>
</tr>
<tr>
<td>12. International Rice Testing Programme</td>
<td>1.90</td>
</tr>
</tbody>
</table>

Total man-years 16.18

47. Each Research Programme team first identifies genotypes that can withstand the stresses within the specific problem area for which they are working. A large number of crosses are then made by the plant breeders to develop numerous experimental lines that are resistant or tolerant to these stresses and have other favourable characteristics, particularly high and stable yields, and pest and disease resistance. Each team member brings to bear his specialized knowledge into the breeding and evaluation programme. Very efficient methods of screening, particularly against some major pests, diseases and adverse conditions have thus been developed. The result is that on the basis of this knowledge 5,000 crosses have currently been made and over 100,000 progenies are handled each year at IRRI. A sizeable number of F₁ material and progenies are supplied worldwide to the national programmes.

48. The teams are mainly located at IRRI headquarters except that one breeder, one entomologist and an agronomist are working in Thailand.

Achievements

49. IRRI has made remarkable progress in the GELJ approach in developing improved varieties with high yield potential and other important characteristics to make them adaptable to a wide range of conditions. IR8 demonstrated improved yield potential but lacked resistance to many diseases and insects. Improved grain quality was combined with high yield potential in IR20, IR22 and IR24 released in 1971. In addition IR20 was resistant to bacterial blight and green leafhopper and moderately resistant to tungro and stemborers. IR26 was the first variety resistant to brown planthopper. Resistance to grassy stunt was incorporated in IR28, IR29, and IR30 and many subsequent varieties and breeding lines. IR36 was the first improved variety which successfully combined most desirable attributes of previous varieties. It is resistant to several of the major diseases (bacterial blight, tungro grassy stunt) and insects (brown
planthopper, green leafhopper, stemborers and gall midge). It is also tolerant to many adverse soil stresses and has some tolerance to drought. The acceptance of IR36 on Asian farms is so great that it is the most widely grown variety of rice today. More than 10 million hectares of rice land in Asia is planted with IR36 annually. Another reason for the wide success of IR36 is its short growth duration. It is 70 days earlier than older traditional varieties. By growing this variety farmers can grow two successive crops of rice in one season on many rainfed Asian farms. IR42 with medium growth duration also has a desirable combination of good grain quality, multiple disease and insect resistance and tolerance to a number of adverse soil conditions. It is grown widely in several Asian countries. Several recent releases are being tried by rice farmers in different parts of the world.

50. Eleven varieties were released by IRRI up to 1975, when it was decided not to name varieties any more. Since then, the Government of the Philippines has released twelve IRRI bred lines as IR varieties. Thus 23 lines developed by IRRI have been released as varieties. Out of these, 19 were recommended for irrigated conditions, two for rainfed lowland and two for upland conditions.

51. In addition, 102 varieties have been released by the national programmes, selected from the improved IRRI materials distributed by IRRI on a global basis. Out of these, 85 have been released in Asian countries, 21 in Africa, and 19 in Latin America. Although some of these varieties may not have been in general cultivation, the IR varieties and varieties selected from IRRI bred materials are planted on approximately 20 to 30 million hectares of rice land in the world, and according to some estimates these varieties contribute US$ 1.5 billion per year by way of increased rice production in Asia. The IRTP has also enabled many varieties, developed by national programmes, to be utilized by other national programmes, both in their breeding work and for direct release. Several major rice countries such as Indonesia and Vietnam are coming close to self-sufficiency in rice production. The Philippines imported rice up to 1976, but became a net exporter in 1978. The exportable surplus in countries like Burma and Pakistan has steadily increased.

52. Besides the releases discussed above, hundreds of IRRI bred lines and varieties are used as parents in the hybridization programmes all over the world and are parents of many varieties bred and released by the national programmes. According to some studies, 70% of the rice varieties released by the national programmes in South and Southeast Asia are either IRRI lines or have at least one IRRI line or variety as a parent.

53. The various Research Programmes leading to the above achievements under GEU are discussed below.

Germplasm Collection, Conservation and Dissemination

54. The Germplasm Bank was completed at a cost of about $2.8 million and inaugurated in November 1977. The facility has a capacity of long-term
storage of 1,300,000 accessions. It is a priceless asset to the rice growing areas of the world and a unique facility among the international agricultural centres.

55. The IBPGR has assigned global responsibility for rice germplasm collection to IRRI. At the time of the inauguration of this Bank in 1977, a Workshop on "Genetic Conservation of Rice Germplasm" was organized at IRRI in which scientists from sixteen countries and three international centres participated. It gave a great boost to the collection campaign. As a result, during the last five years, 7,000 accessions were added to the IRRI collection. They include 1,400 entries from China and more from this country are being processed. Some 5,000 additional entries were received from India, mostly from the remote areas and the Indian accessions now stand at about 20,000. Over 4,000 accessions were received from African sources including over 1,000 accessions of wild species, as well as genetic testers and mutants. A collection of 8,000 varieties with special traits like tolerance to salinity, tolerance to aluminium toxicity, resistance to diseases, pests, etc. was also made and preserved in the national programmes and IRRI's Germplasm Bank. The total accession at present stands at about 60,000. It will thus be seen that additional collections have been made for the traits and from areas identified by the first Quinquennial Review. Collections, however, still need to be made from many parts of the world, particularly from remote and difficult areas. The IBPGR has given some financial support to the cooperating countries and the collection operations are encouraging. An effective computerized information storage and retrieval procedure has been made for effective use of this wealth of material. The data base with important characters has been expanded from 37 to 45 characters. As a result the germplasm material is now widely used all over the world. This is clear from the fact that during the last five years the Bank supplied 22,737 samples of Oryza sativa as a result of 809 requests from national programmes and supplied 167,774 samples within IRRI. In addition, it supplied 5,138 samples of other species as a result of 220 requests.

56. It should be pointed out here that about 5,000 seed samples recently received have not yet been registered and only about 6,000 samples out of 60,000 accessions are reported to have been canned for long term storage. Characteristics of 40,619 accessions have so far been put on computer files. There is a considerable backlog which will not only affect the optimum use of the facilities and material at hand but may also slow down future collections.

57. The main constraints causing this backlog are the following:

(i) The IRRI farm does not provide enough facilities for rejuvenation of the material. When accessions are grown at the IRRI farm, there is an acute problem of pests, diseases and irregularity of water supply. Due to these constraints there is, in many cases, not enough seed to fill the ten (60 gram) cans required by the protocol.
(ii) There is shortage of supporting staff to handle the great amount of work involved and to perform the necessary measurements.

58. To overcome these constraints the Panel recommends that facilities for multiplication of accessions be provided away from the IRRI campus to the Germplasm Bank and that some technicians be added to the staff to cope with this urgent work.

59. The Panel wishes to commend IRRI and particularly the leader of the Germplasm Bank for the accomplishments in this area. However, the Panel also expresses concern about the amount of work involved in conserving, maintaining and evaluating the many collections that have been and would continue to be assembled. The Panel, therefore, recommends that IRRI takes full advantage of the knowledge and experience of the leader in charge of the bank by giving him every opportunity and adequate means to devote all of his time to this unique activity.

60. The Japonica types of rice are difficult to rejuvenate at IRRI. Fortunately this constraint has been alleviated, as the National Institute of Agricultural Sciences of Japan agreed to rejuvenate and store the Japonica types of the collections from China, Korea and Japan.

International Rice Genetic Survey

61. This very interesting project was authorized in 1978 with the objective of establishing permanent records on the genetic ancestry of rice varieties evolved through crosses made in the national programmes. More than 42,000 hybridizations have been compiled. The genetic ancestry of about 600 post-IR8 varieties and 1,200 pre-IR8 varieties has been recorded. The information has been stored on computer files. This information is of immense use to the rice breeders and gives valuable clues to genetic sources of various important characteristics of the rice plant.

62. The Panel recommends that the work be speeded up and made a part of permanent record keeping of the genetic ancestry of all past, present and future varieties of rice in all rice growing countries of the world. The genetic survey should be an integral part of the activities of the Germplasm Bank.

Agronomic Characteristics of Rice

63. The main objective of this programme is to evolve rice varieties suitable for the important rice growing environments which have been broadly characterized as (i) irrigated and rainfed, shallow, favourable, (ii) dryland and rainfed, shallow, drought prone, (iii) rainfed, medium deep, waterlogged (25-50 cm), (iv) rainfed, deepwater (50-100 cm) and floating (> 100 cm), (v) rainfed, shallow, drought and submergence prone, (vi) rainfed, shallow, submergence prone, and (vii) rainfed, medium deep, tidal swamp, or shallow, acid sulphate.
64. This is the rice area where the IRRI varieties have made a major impact starting with IR8. During the last five years nine varieties, namely: IR36, IR38, IR40, IR42, IR44, IR48, IR50, IR52, and IR54 have been named by the Philippine Government (IRRI no longer names varieties) for this cultural type. Out of these IR36 and IR42 are widely grown in the Philippines, which has become a net exporter of rice due to the cultivation of these varieties and the implementation of new technology. These varieties have also been released in several other countries and made a significant impact on production in countries like Indonesia and Vietnam, where they are a key factor in achieving self-sufficiency in rice.

65. Whereas the impact of the IRRI varieties and their derivatives evolved in the national programmes has become remarkable, and is widely acknowledged in the irrigated and favourable rainfed situations, this has not yet been the case in the other environments described above. Only IR43 and IR45 have been found suitable for the relatively favourable dry land conditions and are being recommended. Similarly, the two varieties RD17 and RD19, bred by the IRRI/Thai collaborative project at the deepwater centre, started in Thailand in 1975, have clearly demonstrated their high yield potential, but they are not widely acceptable on account of grain quality and susceptibility to diseases. This development, however, gives the IRRI scientists confidence in their ability to breed varieties for unfavourable situations, provided the strategy of testing the material in the environments for which they are bred is adopted from the beginning.

66. IRRI scientists are very much aware of the fact that the diverse rainfed conditions, under which vast areas of rice are grown in the world, do not occur in the Philippines and therefore materials developed under Los Baños conditions are not likely to be found acceptable, except under favourable rainfed or irrigated conditions, as has been the case for the varieties evolved so far. Hence, there is a need for IRRI to develop varieties for less favourable rainfed situations in collaboration with national research stations located in areas where such conditions occur.

67. A strategy is therefore proposed that, to develop suitable varieties for each of the rainfed situations, tests of segregating populations and selection of appropriate genotypes be done under relevant local conditions. To this end the necessary logistics will have to be worked out with the national research organizations. For example, IRRI could organize teams of IRRI scientists consisting of one breeder, one agronomist, one plant protection scientist, and possibly a physiologist to work on the medium deep, waterlogged situations in India, Bangladesh and Thailand. Similarly, teams could be organized for each of the problem situations mentioned above, to work with their counterparts in the host countries.

68. Such working groups consisting of scientists from IRRI and from
the host country could formulate a joint mode of operation on lines broadly indicated below:

Step 1. Scientists meet and identify parents with appropriate traits and make plans for crosses.

Step 2. Grow parents, make crosses, and grow the F₁ hybrids at IRRI.

Step 3. Plant the F₂ populations at appropriate locations in the target environments and cooperatively select plants with appropriate traits such as suitable growth duration and grain appearance, etc.

Step 4. Grow the F₃ selections at IRRI during the off-season and evaluate for disease or insect resistance, for submergence or drought tolerance, and for grain quality. Rapid generation advance would be helpful in handling selections with photoperiod sensitivity.

Step 5. Plant F₄ selections under target environments and evaluate for plant type, growth duration, and select for adaptability to field problems.

Step 6. Grow selected materials as F₅ progeny rows at IRRI and again evaluate for traits which require laboratory, greenhouse and field tests for which IRRI has facilities.

Step 7. Plant F₆ materials in target environments in progeny rows, as well as in observational or preliminary yield trials.

Step 8. Multiply the seed of selected rows at IRRI as well as conduct confirmatory tests for various traits.

Step 9. Conduct replicated yield trials in target environments and identify the most promising lines.

Step 10. Repeat the replicated yield trials, identify, test and exchange promising lines through IRTP, and select materials for on-farm trials.

Step 11. Release varieties under local names.

The above procedures may be considered as a guideline and could be finalized after the working groups have been formed and have started operating.

69. Although the IRRI coordinated International Rice Testing Programme (IRTP) is large and comprehensive, a review of the work on identification of varieties clearly indicates that at present, IRRI is not yet in a position to identify suitable varieties developed in its GEU programme for testing under the various rainfed situations, so as to be adopted by the countries concerned, even though IRTP is an effective procedure for screening of genotypes against pests and diseases and adverse soil conditions.
70. It would, therefore, be worthwhile to consider a closer integration of IRTP and plant breeding activities. This appears to be a more productive approach for the development of varieties suitable for specific rainfed situations.

Recommendation

71. Adoption of the above strategy would require a review of the staff positions in plant breeding. The Panel recognizes the importance of cooperative research among plant breeders, but recommends that individual responsibility be assigned for breeding work for the following conditions: (i) irrigated and rainfed, favourable, (ii) rainfed, shallow, (iii) rainfed dryland, (iv) rainfed, medium deep, waterlogged, (v) deep-water and floating.

Innovative Breeding Approach

72. IRRI's breeding strategy so far has been to change the plant type through conventional breeding methods so as to become more responsive to high inputs. This strategy has been very successful, particularly in favourable environments. There is, however, a general feeling among most rice scientists that this strategy will satisfactorily maintain the present yield level under favourable conditions and will possibly have some impact on rice yields under some unfavourable environments, but it is not expected to result in another quantum jump in yield potential. It is, therefore, imperative that IRRI plant breeders not only keep abreast of the new approaches in plant breeding but also explore new horizons to evolve rice genotypes with higher yield potential and stability than is possible through conventional breeding methods.

73. IRRI has already taken the initiative in innovative breeding techniques and the present status of some of these is discussed below.

Hybrid Rice

74. Chinese scientists have been working on hybrid rice for quite a time and at present China is reported to be growing six million ha of hybrid rice or about 17% of its rice area. The hybrids have shown a yield advantage of 20 to 30%, which makes them economically attractive. Although IRRI had initiated this work in the early seventies, it was discontinued in favour of traditional breeding methods. The work was revived in 1979 mainly on account of the stimulus provided to IRRI scientists by their contact with the Chinese scientists who had made a success of this approach. Impressive progress has been made since then. Several cytoplasmic male sterile lines have been collected and a large number of maintainer and restorer lines have been identified. Data from field experiments show yield increases of up to 30% over the best non-hybrid varieties.
75. The F1 hybrids generally showed early vegetative vigour and increase in root mass indicating that this breeding approach may also be useful for rainfed rice. The seed production technology seems to be simple enough for adoption by farmers in the developing countries, particularly in the more advanced rice growing areas.

76. On account of the relatively low seed rate, especially under transplanted conditions, the higher costs of seed may not be a serious constraint to the adoption of hybrid rice. The cost benefit ratio seems favourable to this approach but IRRI should gather more data on this practice.

77. Considering all aspects of the matter, the Panel came to the conclusion that the work should continue and not be interrupted for at least the next five years by which time definite judgement about its merits should be available.

78. Embryo culture. With encouraging results obtained from inter-specific crosses, particularly in incorporating genes for disease resistance from wild types, the scope for wide crosses needs to be expanded. These crosses may not be possible through sexual process in all cases on account of embryo abortion or the inability of the embryo to mature. Preliminary work on embryo culture has shown promise of overcoming this difficulty. It is desirable to expand this work to obtain viable plants for inter-specific crosses as well as to overcome the sterility barrier in certain hybrids.

79. Anther culture. This technique may be a useful tool in screening recombinants, although preliminary work shows that callus formation is variable among the various genotypes.

80. Somatic cell culture. This work is directed towards obtaining lines tolerant to high soil salinity. The work is at a very preliminary stage but appears worthwhile enough to be pursued.

81. As IRRI's breeding programme is at a stage that these new techniques must be explored, the Panel recommends that a scientist should be hired for this work. Such a scientist should have experience in tissue culture work and a good background in plant breeding.

82. If hiring a scientist is not feasible because of financial constraints, a post doctoral or visiting scientist should be considered, although by the nature of the work a long term programme remains desirable.

Insect Resistance

83. IRRI's programme on identification of genes for insect resistance and their planned incorporation into successive improved varieties has been outstanding and has paid rich dividends. Six genes for resistance to brown planthopper (BPH) have been identified. The first BPH resistant variety IR26 with BPH1 resistance was released in 1973 and was widely grown in the Philippines, Indonesia and Vietnam. Three years after its
release and widespread cultivation, a new biotype of BPH capable of attacking IR26 developed in the same countries. IR36 which has BPH2 gene for resistance to BPH was then released. This variety and several others with the same gene have been widely cultivated in the Philippines and many other countries of Asia for the last five years and have maintained their resistance. Meanwhile BPH3 and BPH4 have been incorporated into improved germplasm and these materials are available for release if the varieties with BPH2 become susceptible. This sequential release strategy has been highly successful in controlling the BPH in most parts of Asia. More than 20 million hectares of rice land in Asia is now planted to BPH resistant varieties developed by IRRI. Genes for BPH resistance are also being pyramided into single varieties.

84. Eight different genes for resistance to green leafhopper have been identified and incorporated into improved varieties. All the IRRI varieties except IR22 are resistant to green leafhopper and have at least one of these genes. Four genes for resistance to whitebacked planthopper and three for resistance to zigzag leafhopper have been identified and are being incorporated into improved germplasm. The work on identification of genes for insect resistance, an outstanding example of the multidisciplinary approach of CEU, is very rewarding in improving and stabilizing rice yields. Although IRRI scientists have identified additional genes for assistance to brown planthopper, the work on screening germplasm for additional sources of insect resistance must continue to be vigorously pursued (ref. para. 135).

Disease Resistance

85. Most of the rice germplasm collection at IRRI has been screened for resistance to major diseases and many accessions have been screened even for minor diseases. Sources of resistance to some of the major diseases have been identified. In the case of bacterial leaf blight, resistant sources to all known strains have been identified. Resistance genes to some of these have been characterized. Some of the pathogens causing rice diseases such as the blast fungus are very variable and hence incorporation of resistance to the large number of races is difficult. On the other hand diseases like grassy stunt and tungro have been effectively controlled through breeding for resistance against the vector and the virus (ref. paras. 110, 111).

86. The work on screening of varieties against diseases, particularly rice blast, needs to be vigorously pursued. The positions in the department of Plant Pathology need to be speedily filled and a long term programme developed.

Grain Quality and Nutrient Content

87. IRRI varieties have shown progressive improvement in grain quality attributes, such as shape, size, appearance of the grain, translucency, and milling recovery, resulting in better consumer acceptance compared to the earlier introductions like IR8 and IR5. Emphasis has been on inter-
mediate amylose content in response to consumer preference in the rice consuming countries. Simplified amylose tests have been further refined for quick screening of the large numbers of varieties. The major work on protein has been monitoring protein content and identification of a few high protein lines. The department is adequately equipped in scientific manpower for this type of work. The Panel suggests that the priority given to this programme should be re-examined in the context of other demands.

### Drought Resistance

88. Rice is grown under drought stress of varying degrees in many parts of the world, particularly under rainfed shallow conditions. The area under dry land is estimated at 19.1 million ha and that under rainfed shallow at 29.7 million ha. Incorporating tolerance to drought in varieties is thus very important.

89. Out of over 50,000 lines screened for drought tolerance, over 4% showed drought resistant characters. Two varieties, IR43 and IR45, have been identified as having some degree of drought tolerance.

90. The major constraint in this work is that it is location specific and should be carried out in collaboration with appropriate national programmes, rather than at the IRRI farm.

### Adverse Temperature Tolerance

91. This trait relates to both extremely low and extremely high temperatures. Work on screening for cold tolerance with Korean collaboration progressed well. Varieties like RPKN-2 have been identified. For temperatures above 35°C, test locations have been identified in Saudi Arabia, North India and other places. Obtaining cooperation and providing support for work at suitable sites are constraints.

### Deepwater and Flood Tolerance

92. This work has been in progress in Thailand where IRRI has posted three senior scientists. Two varieties, RD17 and RD19 have been released. Further work to incorporate better grain quality into these varieties is progressing well.

### Adverse Soil Tolerance

93. Large areas in Asia otherwise suitable for rice culture remain uncropped or produced marginal crops because of soil problems such as salinity, alkalinity, acidity and excess organic matter. Screening of genotypes for such conditions has been undertaken to identify sources tolerant to such conditions.

94. Over 74,000 lines have so far been screened and a large number of elite lines identified. IR42 has shown remarkable adaptation to such conditions.
95. The work is site specific and should be undertaken in actual problem areas. Tissue culture technique should also be further explored to achieve adverse soil tolerance. Zinc and phosphorus deficiency need special attention in screening.

International Rice Testing Programme (IRTP)

96. IRTP began informally in 1963 when the first international rice nursery was started, primarily to screen rice genotypes against diseases in hot spot locations. The first international rice breeding nursery was organized in 1973. IRTP was formalized in 1975 with support from UNDP. Its objectives are:

- to make the world's elite germplasm available to rice scientists all over the world for direct use;
- to provide scientists with an opportunity to assess the performance of their own advanced breeding lines over a wide range of conditions;
- to identify varieties with a broad spectrum of resistance against major diseases, insects and other stresses;
- to promote interaction among rice scientists all over the world.

The network covers over 800 scientists working at over 300 stations in 75 countries. Over 20 types of nurseries are distributed each year. The number of nursery types multiplied by the number of entries per nursery amounts to about 1,500. Some 60% of the entries originate from national programmes, 35% from GEU, and 5% from the germplasm bank.

97. According to the information collected from IRTP reports, progress has been mainly in the favourable rice growing areas, and little progress was made in medium deep, deepwater and upland rice growing conditions. Slow progress may be due in part to the fact that varieties bred at Los Baños, where such conditions do not exist, are not found suitable to unfavourable growing conditions. IRRI is advised to start testing of lines at specific adverse locations only after suitable material has been generated as a result of breeding procedures indicated in para. 68. Meanwhile, IRRI could confine its testing to hot spot locations for the identification of parents for breeding programmes.

98. It is tempting to try and make a cost-benefit analysis of IRTP. This is, unfortunately, not feasible. One good variety resulting from IRTP outweighs all costs. The Panel has, on the one hand, not encountered firm evidence that such widely used varieties were the result of IRTP and that they would not have been obtained otherwise; on the other hand, the Panel is convinced of the usefulness of testing breeding material in disease and pest hot spots and in localities with specific stresses. The Panel also acknowledges that international cooperation among rice scientists can be promoted by common visits to
IRTP sites, but the Panel has no means of assessing the value thereof. The Panel suggests that IRRI carefully reconsider the numbers and sizes of the IRTP nurseries as well as the type of entries to be tested, in view of the workload and costs for both IRRI and those who plant and tend the nurseries.

99. IRTP could be instrumental in disease and pest surveillance or monitoring if sites are well chosen, nurseries well observed, and resulting data well interpreted. Though the Panel was assured that IRTP was also used in this way, the Panel did not see the evidence. In fact, this type of work needs a rather sophisticated computerized approach. Furthermore, the Panel suggests that IRTP be linked more closely with the breeding programme.

Integration of the GEU

100. GEU as a multidisciplinary approach to the development of rice varieties has been quite productive. The continued productivity of this programme will primarily depend upon the genetic manipulation of the wealth of germplasm material now available at IRRI, which has been a key factor for the success so far achieved. The Panel, however, felt that to put this programme on a firm footing it would be desirable to nominate one of the scientists from the team working in GEU as coordinator of the programme.

(b) Control and Management of Pests and Diseases

Background and Objectives

101. Crops, and certainly crops in the tropics, are subjected to damage by countless harmful agents: insects, fungi, bacteria, viruses, weeds, birds, and rodents. Crop protection problems have been complicated by the narrow genetic base of modern varieties, increased frequency of rice croppings, increased application of N-fertilizer, and inappropriate use of pesticides. Crop protection methods can be grouped into four broad approaches: (i) varietal control, (ii) chemical control, (iii) cultural control, and (iv) biological control. Each of these approaches has its pros and cons. Lack of durability is a handicap in (i) and (ii), organizational complexity in (iii) and (iv). Overdue reliance upon any single approach entails great risks. Varietal control is the most important approach as it is highly cost-effective and free from undesirable side effects. It must, however, be supplemented by other approaches. In view of this, IRRI is gradually moving towards "integrated pest and disease management", in which each of the approaches has its appropriate place, with varietal control through resistance as a basis. The objective is to stabilize the crop-ecosystem at minimum risk, minimum costs, and minimum pollution. Harmful agents are to be kept at or below economically acceptable threshold levels. The necessary knowledge and technology must be acquired through basic and applied research. With respect to tropical rice little information is available "on the shelf".
IRRI has identified crop protection as Problem Area No. 2, Control and Management of Rice Pests. "Pests" apparently must be read in the wide sense, including diseases, as in "pesticides". The Problem Area is subdivided into three Research Programmes:

- Control and management of rice diseases
- Control and management of insect pests of rice
- Control of management of weeds in rice paddies

The GEU components:

- Disease resistance, and
- Insect resistance

are also discussed in this chapter. The major departments involved are Entomology, Plant Pathology, Plant Breeding, and Agronomy; several other departments contribute in one way or another.

IRRI extends training in crop protection technology and logistic services to individuals from national programmes. In 1981, the first course on Integrated Pest Management was held, which emphasized the integrated approach to the control of diseases, insect pests, rodents, weeds, and so on. About 15 M.Sc., 9 Ph.D. and numerous non-degree students received a one to four months training in research during the past quinquennium.

The Panel endorses IRRI strategy as formulated above. The Panel expresses its concern with respect to the genetic vulnerability of the modern rice crops. Millions of hectares are covered by a single genotype; IR36 for example covers over 10 million ha. If a particular harmful agent becomes adapted to that genotype, a catastrophe may occur which could threaten the lives of many people. The extensive epidemics of tungro virus disease in the recent past contain a message in this respect. The Panel suggests the development of specific measures to reduce the vulnerability by increasing genetic diversity and by gene deployment strategies, and to keep the situation under scrutiny by intensive monitoring.

The recommendations of the first Quinquennial Review Panel regarding pest management have been realized with the following exceptions:

(i) The first Quinquennial Review identified the possible need of a rice nematologist. IRRI decided to keep this recommendation under review, a decision so far justified by the facts. The Panel suggests that IRRI acquire nematological expertise, when needed, on an ad-hoc basis.

(ii) The first Quinquennial Review identified the need for another senior plant pathologist. Though TAC's approval for an additional position of a senior plant pathologist was obtained in 1981, IRRI has not yet filled the position, much to the concern of the Panel.

(iii) The first Quinquennial Review recommended that the testing of pesticides be reduced to the minimum level compatible with the identification of potentially useful compounds. IRRI states that it complies with this recommendation even though the number of insecticides tested has approximately doubled. The Panel reiterates the recommendation of the first Quinquennial Review Panel and it suggests the utmost reservation in the acceptance of coded compounds.
106. The problem area is covered by senior scientists from various departments. Total staff of Entomology plus Plant Pathology amounts to ten persons, including the two vacancies in Plant Pathology. The relative strength of Entomology is evident. The Panel regrets the vacancy in the position of the Head of the Department of Plant Pathology, which led to discontinuity and lack of leadership. The Panel deplores the fact that the vacancy of Senior Plant Pathologist could not yet be funded. The available manpower in entomology and weed control is considered to be satisfactory. The Panel appreciates the great contribution to the entomology component made by visiting scientists working under various formal arrangements.

107. The recommendation of the first Quinquennial Review Panel to construct additional greenhouses and screenhouses has not been completely realized due to cash limitations. Laboratories are thought to be adequate. Identification and further study of rice viruses is seriously hampered by the absence of an electron microscope with corollary equipment. Lack of an electron microscope is developing into a serious constraint as identification and purification of viruses cannot be done. Consequently morphological, etiological and epidemiological studies of rice viruses are not at a satisfactory level of scientific proficiency (ref. para. 473).

108. The two rice blast nurseries are, for various reasons, thought to be inadequate. A new site for a blast nursery has been identified and plans are in preparation to implement the nursery with screens, wind shields, water for strictly supervised irrigation, monitoring equipment for epidemiological studies, and a small building. The Panel suggests that the blast nursery be established with expediency once the present staff vacancies are filled.

Diseases

Main Achievements

109. Varietal control of diseases is realized through the GEU component "Disease Resistance". The objective is to reduce losses and procure yield stability by means of multiple disease resistance. To this purpose resistance to many diseases and their races/strains must be incorporated into one single rice genotype. As all these resistances are governed by different genes, extensive hybridization and testing is necessary. Primary screening of new successions must be fast and efficient. To this end, existing screening methods have been continuously improved and new ones developed.

110. The output of the screening efforts has been prodigious. Greenhouse and/or field methods have been developed for tungro, grassy stunt, ragged stunt, bacterial blight (inoculation method improved), bacterial streak, blast sheath blight, sheath rot, stem rot, bakanae, brown spot,
narrow brown leaf spot, and leaf scald. Bacterial and sheath blights are field tested in the GEU accession multiplication plots, thus saving time and field space. Over 700,000 entries in total have been evaluated at a rate of over 5,000 a year. There is no backlog in screening.

111. Multiple resistance to at least six diseases has been accumulated in released varieties and breeding lines. New lines with multiple resistance are available "on the shelf" in case of emergencies. Significant reductions in grassy stunt and bacterial blight have been realized through the introduction of resistant varieties. The Panel commends the rapidity with which grassy stunt has been brought under control by means of interspecific hybridization with Oryza nivara.

112. In South Korea, a rice blast management system is introduced with assistance of IRRI, based on "gene rotation". IRRI has decisively contributed by off-season seed multiplication. In view of various uncertainties, the Panel suggests that this system be kept under close scrutiny.

113. Chemical control. Research on chemical control of diseases has been kept at a low profile. Little attention has as yet been given to economic thresholds and cost-effectiveness.

114. Cultural control. Adequate weed control is instrumental in reducing sheath blight. Avoidance of lodging reduces stem rot to a relatively unimportant disease. Attention was given to crop health by means of seedbed treatment.

115. Biological control of sheath blight by means of the fungus Trichoderma may be feasible.

116. Base-line studies. A few important studies are mentioned here. (i) A regional Rice Tungro Virus Collaborative Project (S and SE Asia) investigates variation in varietal resistance against virus strains and hopper biotypes. (ii) Strains of Xanthomonas campestris pathovar oryzae have been differentiated and collaborative efforts for strain characterization have begun. (iii) A new virus disease, rice ragged stunt, has been identified; it is transmitted by the brown plant-hopper Nilaparvata lugens. (iv) Several propagation techniques and inoculation methods for rice pathogens have been improved. (v) Stem rot has been identified as a secondary disease, with low research priority.

117. Disease monitoring and forecasting. Marked advances have been made in the monitoring and forecasting of tungro. The method is ready for application and is adopted by the Bureau of Plant Industry of the Philippines. A first training course "Monitoring of the rice tungro disease in the Philippines" has been given to eight trainees in 1981 and another one is foreseen for 1982. The necessary monitoring equipment (60 kits) will be obtained from a donor country.
118. The Panel must point to the lack of results in the area of rice blast research. Using the Philippine rice blast differentials IRRI identified some 260 races, which shows that the rice blast fungus is extremely variable. As the addition of another differential variety doubles the possible number of races, numbers of races rapidly become unmanageable. Without denying the usefulness of race identification, the Panel cannot but conclude that rice blast research has come to a standstill. This is even more so when upland rice is taken into consideration: the upland conditions are very conducive to blast outbreaks. IRRI's advances in the epidemiology of rice blast have been modest. The genetics of the fungus have been left untouched by IRRI. The Panel has come to the conclusion that the research situation at IRRI with respect to rice blast is at a critically low level.

Constraints

119. Vacancies in the staff have been a serious constraint to the progress, especially in mycology.

120. The lack of an electron microscope with its accessories and trained staff is a serious handicap: diagnostic work and studies on the identity of viruses and on infection processes cannot be performed in-house. For example, the various forms of tungro may be related to the relative frequencies of the two virus particle types involved. IRRI cannot do research nor can it give guidance in this area.

121. A physical constraint is the inadequacy of the present blast nurseries, as discussed above.

122. There are several scientific constraints. A good field method to separate leaf blast from neck rot is not available. There is a great lack of knowledge on the genetics of resistance and the genetics of pathogenicity with respect to most diseases. Partial resistance to blast and sheath blight is difficult to measure and inadequate under conditions highly conducive to disease.

123. Apart from more basic research, attention of the GEU component "Disease Resistance" is focussed on (i) exploiting various breeding strategies, and (ii) collaborative efforts by way of the International Rice Research Conferences, IRTP disease monitoring tours, and joint pathologist/breeder monitoring tours or workshops.

124. IRRI workplans are aimed at the following items: (i) disease monitoring tour; (ii) etiological studies; (iii) epidemiological studies; (iv) seed transmission; (v) chemical controls; (vi) biological and cultural control; and (vii) collaborative projects.

Discussion of Priorities

125. Varietal control. The Panel considers the current GEU "Disease Resistance" programme to be good; it should be maintained at the present
level. For some diseases, among which are hopefully tungro and sheath blight, higher levels of resistance might be found in wild rice species. The Panel suggests that continued attention be given to resistance against tungro (and its eventual strains) as distinct from resistance to its vector, the green leafhopper. Special methods to distinguish the two forms of resistance should be elaborated.

126. The Panel recommends "sequential release" of resistance genes as the standard strategy, and "gene deployment" and "pyramiding" as possible alternatives when new races or strains of a pathogen appear. The Panel suggests that continued efforts be made to find and utilize forms of "stable", "horizontal" or "slow diseasing" resistances, preferably in combination with vertical resistance, especially for rice blast and sheath blight.

127. Chemical control. Studies on chemical control of fungal and bacterial diseases must be continued, economic threshold levels established, and cost-effectiveness demonstrated first in field trials and then in farmers' fields. Resistance of fungi and bacteria against fungicides is to be anticipated. The Panel suggests contracting out resistance studies to specialized laboratories in developed countries.

128. Cultural control. The Panel suggests maintaining cultural control as a specific item and to consider under this item matters such as health of seeds and transplants, sanitation (removal of plant remnants and weeds carrying inoculum), crop rotation, and so on. Cultural control may be important, especially in dryland farming (cropping systems).

129. Biological control. Generally speaking, biological control of fungal and bacterial diseases has been shown to be extremely difficult. The Panel suggests this approach be given low priority.

130. Seed transmission. The Panel expresses its concern about the possibility of seed transmission of diseases with GEU and IRTP seed samples entering or leaving the Philippines. Several diseases are seed transmitted. IRRI must avoid bringing a new disease into the Philippines or another receiving country by IRRI seed transfers. The Panel appreciates the thought given to this problem, possibly resulting in the stationing of a Bureau of Plant Industry seed pathologist at IRRI. The Panel suggests that this possibility be pursued, even at some expense to IRRI. The Panel suggests that procedures in handling incoming and outgoing seeds be rigorously defined and adhered to.

131. Rice blast. No simple solution for the standstill in rice blast research is available. Innovative research on etiology, epidemiology, physiology and genetics of the fungus is needed as well as the exploration of new approaches to the genetics of resistance in rice against *Pyricularia oryzae*. This requires a team approach, in which the new Senior Pathologist can only be the nucleus and stimulator. The Panel suggests that close contacts be maintained with colleagues abroad (especially in Brazil, France and USA) and that frequent consultations be organized. Rice blast under upland conditions must be an essential component of the total blast programme. The Panel assigns top priority to rice blast research.
132. **Tungro.** Good research has been done on tungro epidemiology. Aspects of tungro research that need further elaboration are: (i) varietal control (more resistance genes needed, partial resistance to be increased, utilization of resistance in wild rice species, variety testing in hot spots), (ii) biotypes of the green leafhopper, (iii) strains of the virus, (iv) disease and vector monitoring, and (v) verification and cost-effectiveness of forecasting methods. The Panel assigns second priority to continued and intensive tungro research.

**Conclusions and Recommendations**

133. The Panel suggests ranking the research priorities in the following order: (i) Rice blast research (all aspects). (ii) Tungro research. (iii) Economic thresholds and cost-effectiveness of fungicides. (iv) Disease monitoring. (v) Maintenance research. (vi) Biological control.

134. The Panel recommends that at least one Senior Plant Pathologist be assigned to rice blast research and that a task force of internal and external advisors be formed in order to approach the rice blast problem in an innovative way.

**Insects**

**Main Achievements**

135. **VARIETAL CONTROL.** The productivity of the GEU-component "Insect Resistance" was outstanding. (i) Some 60,000 accessions per year can be tested in the greenhouse against various species and biotypes of hoppers. Greenhouse tests are available against various hoppers, stem borers, leaf folder and rice bug. Brown planthopper resistance is also tested in the field (advanced growth stages). Resistance against yellow stem borer is tested in a hot spot. (ii) Sources of resistance have been found against brown planthopper, green leafhopper, zigzag leafhopper, whitebacked planthopper, yellow and striped stem borer, leaf folder, and whorl maggot. Identification of resistance genes against brown planthopper, green leafhopper and whitebacked planthopper has begun and some of the genes identified have been incorporated into newly released varieties and have helped to control outbreaks of these insects. As new biotypes may appear new resistance genes have been incorporated in breeding lines held in stock to cope with emergencies. (iii) Special techniques have been developed to predict whether a new resistance gene will be rapidly overcome by the brown planthopper or not.

136. **CHEMICAL CONTROL.** Control chemicals have been tested in conjunction with application methods: seed treatment, seedbed treatment, granules applied to soil of irrigation water, foliar application and rootzone application. "Botanic chemicals" (extracted from plants) have been selected and tested; they show few or no undesirable side effects.

137. **CULTURAL CONTROL** by short duration varieties is feasible. Insect
"shifts" have been observed; short stature varieties tend to decrease stem borer and increase brown planthopper populations. Studies in simultaneous planting have been initiated.

138. Biological control. Natural enemies provide biocontrol. The effectiveness of ducks has been shown. Spiders can be effective in hopper control. A hopper egg parasite can be reared in the laboratory. Fungal pathogens of insects are under investigation.

139. Resurgence is the effect that, after insecticide treatment, an insect population becomes more damaging than before and/or more damaging than the untreated check. Resurgence is a general phenomenon. It is a cause of "hopper burn" by the brown planthopper. The causal mechanisms have been explained. Insecticides can now be classified according to their relative advantage with respect to avoidance of resurgence and those conducive to resurgence can be banned by the regulatory authorities. Conversely, the undesirable insecticides can be utilized to solicit resurgence in order to increase the population density of the brown planthopper for the purpose of varietal resistance testing.

140. Insect biology. Good progress has been made in the areas of taxonomy, ecology, behaviour, and insect rearing. Collection and identification of rice insects and their parasites and predators is the cornerstone for all insect control studies. Sampling methods for leafhoppers, planthoppers and leaf folders have been developed to the extent that they can be tested in population dynamics studies within cropping periods. Methods have been developed to rear the leaf folder and the caseworm in the laboratory so that variety testing becomes cheaper, faster and more reliable.

141. Insect Pest Management. Sampling methods have been developed for the major insect pests. Economic thresholds have been established and chemical control methods identified. Insect Pest Management is presently being tested in farmers' fields.

142. Neem (Azadirachta indica, a tropical tree). A major effort, mainly from special project funds, is being made in the exploration of neem botanical chemicals as pesticides. The prospects are good as neem products can be grown and processed locally and cheaply; they have few or no undesirable side effects.

143. Brown planthopper. A concerted effort, mainly based on special project funding, has led to the elucidation of brown planthopper biology. Morphology, physiology, behaviour, population dynamics, distribution ecology, biotypes, and antibiosis have been studied in an integrated approach. A large body of knowledge has been accumulated and published or prepared for publication. This outstanding work could not have been done without the contributions of an ICIPE core-funded (formerly ADAB-funded) scientist and two ODA scientists seconded to SEARCA, who work with the project.
Constraints and Future Work Plans

144. The entomology programme is strong and well-staffed. The only constraint to rapid progress in GEU "Insect Resistance" is manpower. One position for a plant breeder is available but not filled. Another plant breeder with supporting staff is necessary, according to IRRI's Head of the Department of Plant Breeding.

145. Work plans for the next decade are well specified. (i) Insect resistance. The future plans are (1) to continue the ongoing work, (2) to expand the screening and breeding programme to other pre- and post-harvest pests, and (3) to use modern breeding methods to overcome interspecific fertility barriers and/or inadequate resistance levels in parent material. (ii) Pest emphasis. Considerable resources have been used in the concerted effort on brown planthopper. As this study comes to a close, resources can be diverted to other pests including epidemic types such as green leafhopper, whitebacked planthopper, leaf folder, and endemic types such as rice bug, stem borers, whorl maggot, leaf roller and thrips. The Panel suggests that research on brown planthopper should be kept at a relatively high maintenance level. (iii) Collaborative research with national programmes. IRRI thinks the time has come to prepare and establish an international network for the joint development and testing of Insect Pest Management strategies including monitoring for surveillance and forecasting, population dynamics, economic thresholds, migration and biocontrol. (iv) Training. IRRI expects to extend and intensify formal training courses and training in specialized subjects and provision of information through literature services, type specimens, annual reports and manuals. (v) Basic studies in all components of entomology will be continued with a view to strengthen varietal testing and pest control. (vi) Applied studies. IRRI plans to develop IPM packages for different types of rice growing in conjunction with other relevant disciplines, and to integrate insect, disease, vertebrate and weed control into agronomically and economically acceptable packages.

Priorities and Recommendations

146. The Panel considers the approach in entomology to be balanced and comprehensive. The Panel recognizes the GEU programme "Insect Resistance" as very effective with a high pay-off. Multiple resistance against a variety of harmful agents has been obtained. No major change of emphasis is needed in GEU "Insect Resistance". The Panel recommends that the vacancy for a Senior Plant Breeder be filled to maintain the thrust of the programme.

147. The Panel stresses the need to develop methods to identify and breed for moderate levels of resistance, that may be adequate in some places and that can play a role in integrated pest management systems in others.

148. The Panel suggests the continuation of basic work in taxonomy, ecology, behaviour, and population dynamics at maintenance level.
The Panel suggests that insecticide testing be limited as to the numbers of chemicals tested, that coded chemicals normally not be considered, and that emphasis be placed on application methods, especially root zone application and ultra-low-volume foliar application. A link with the Agricultural Engineering Department is suggested. More attention be given to synergistic effects of pesticides and to their environmental effects, including those on fish, poultry, and cattle.

The Panel suggests that the results of the comprehensive studies on brown planthopper be translated into practical methods of monitoring, forecasting, and integrated control, and - after due testing - channelled into an international network. This being achieved the Panel recommends that resources be redirected as indicated above.

The Panel suggests that the idea of an international network in Insect Pest Management be explored and to establish this network if agreeable to national programmes. As the endeavours in IPM for rice-based cropping systems can be channelled through the Cropping Systems Network, it would suffice - at least in the beginning - to limit the IPM network to irrigated rice. Such an approach would also acknowledge that the problems in irrigated and rainfed rice tend to be different. Special attention is to be given to the training component and to the financial aspects of such a network.

The Panel recommends the widening of the Insect Pest Management concept to an Integrated Pest and Disease Management concept, involving the cooperation of, among others, plant pathologists and weed scientists. To do so effectively will probably require a concerted effort for the whole of IRRI's third decade.

The Panel suggests the continuation of the IRRI/ICIPE cooperation through the stationing of an ICIPE core-scientist at IRRI.

The Panel suggests the following order of priorities: (i) Insect resistance in all its aspects. (ii) Development of complete insect pest management packages including monitoring, population dynamics, economic thresholds, and control with the brown planthopper as the main target for the time being. (ii) Integration of these packages with disease and weed control into Integrated Pest and Disease Management systems according to rice cultivation types. (iv) Research on the application of pesticides and on safety precautions, rather than continued testing of compounds. (v) Maintenance research over a broad area, at a fair level of intensity.

The Panel recommends maintenance of the core-manpower in entomology at the present level.

Weed Control

Background and Objectives

Weed research has been a part of the IRRI Programme since the beginning of the Institute. Early work emphasized chemical weed control.
in irrigated rice. This work produced useful and practical control measures that farmers were able to apply as they adopted the modern varieties. However, more recently, as weed problems have changed with cultural practices and as IRRI has begun work on less favourable environments, the research now gives more attention to understanding weed ecology, weed biology, weed shifts, build-up of perennial weeds, and places more emphasis on cultural control and weed management. Studies of the economic benefits and constraints of weed control have been carried out by IRRI economists. Also, weed control and weed associated losses were factors examined in the 'constraints to production' research carried out in farmers' fields.

Means - Personnel, Facilities

157. Personnel. The research is carried out by two core scientists in Agronomy, who have divided responsibilities between them on the basis of the type of rice production. One scientist works part-time on wetland (irrigated and rainfed), upland and deepwater problems, the other works full-time on dry-seeded rainfed bunded rice and is heavily involved in the Cropping Systems Programme.

158. The work is conducted under two Problem Areas, Pests of Rice (Programme - Control and Management of Weeds in Rice) and Cropping Systems (Programme - Pest Control in Rice-based Cropping Systems).

159. Facilities at IRRI for the research are excellent. However, much of the research for the Constraint and Cropping Systems Programme is carried out in farmers' fields.

Achievements

160. Improved understanding of weed problems in irrigated rice has been gained, and effective control measures employing a combination of cultural and chemical control have been achieved. Both pre-emergence and post-emergence chemical control measures have been worked out for transplanted and direct-seeded irrigated rice.

161. Changes in weed flora with introduction of the modern varieties, use of herbicides, and changes in tillage and water management have caused a shift from annual weeds to perennial species such as *Scirpus maritimus*. IRRI scientists have studied such weed shifts, and have worked out control measures against it.

162. In cooperation with economists, entomologists, and other scientists in the Constraints and Cropping Systems Programmes, the weed scientists have worked out methodologies for surveying and studying weed problems and associated losses on farmers' fields. Such information is being needed to improve weed research in rainfed rice. A major symposium on "Weeds in Rice" was held in August 1981, which helped to define research needs and collaborative efforts required to improve weed control.
for the various kinds of rice production systems.

Constraints and Future Plans

163. The major constraint is the lack of sufficient trained weed scientists in the national programmes.

164. Efforts will centre more on improving the understanding of weeds as organisms, their biology, ecology, causes for shifts in populations under different rice management systems, responses to water management, and so on. Such information will provide a basis for control and management practices designed to fit the phenology and ecology of problem weeds. Deepwater rice will receive more attention and the stationing of a rice agronomist at the Thailand rice research station will help in this regard. As understanding is gained with the major weed problems of rainfed rice, emphasis will increasingly be placed on development of control measures that fit the farm conditions. Briefly, plans are to continue lines of research already built-up: (i) Weed control technology at farm level in various rice production systems, with more emphasis on direct seeded rice. (ii) The study of the biology of weed species in a more comprehensive way, including ecology, allelopathy, and natural enemies. (iii) Identification of rice cultivars that are competitive against weeds. (iv) Determination of the environmental effects of herbicides. (v) The Study of cost-effectiveness of weed control methods.

165. The Panel has found the programme on control of management of weeds to be a broadly based, good and successful programme, well integrated over all relevant IRRI departments, directly aiming at farmers' needs.

166. As international collaborative programmes are difficult to implement due to lack of suitably trained counterparts, IRRI will consider the possibility of establishing a three-month weed control training course. The Panel expresses its concern about the apparent lack of expertise in national programmes and the lack of interest on the part of students and post-graduates. Perhaps this is a reflection of the lack of awareness and interest by national leaders in the importance of weed losses and in effective study and control of important weeds.

Conclusions

167. The Panel recognizes the importance of studying (i) the cost-effectiveness of various weed control methods, (ii) the biology of weeds, and (iii) the side effects of herbicides (sorjan cultivation, persistence, Azolla, fish). In view of the difficulties encountered elsewhere the Panel gives low priority to biological control of weeds.

168. The Panel supports the idea of a weed control course which may be instrumental in disseminating the expertise needed to eventually establish a weed control network.
(c) **Irrigation Water Management**

**Background and Objectives**

169. No case needs to be made for the importance of irrigation in the production of high yields of rice. An adequate supply of good quality water is so essential that IRRI directs considerable research toward the solution of problems of distribution and utilization. The Irrigation Water Management Department has primary responsibility for water management research although important cooperation is received from other departments, especially Economics and Agronomy. The programme has close links with national programmes, especially the Philippine National Irrigation Administration (NIA) with which IRRI is carrying out several collaborative studies, and the national programmes of Indonesia and Bangladesh, where joint projects are being initiated.

170. The objectives of the programmes are: to improve the technical, managerial and socio-institutional factors determining the potential and actual utilization of water in rice irrigation systems; to develop and determine the effectiveness, through pilot test projects, of alternative methods of water distribution and allocation in different types of irrigation systems; and to develop practically useful criteria for irrigation system planning, design and rehabilitation.

**Means - Personnel, Facilities**

171. The programme involves two senior staff members of the Irrigation Water Management Department, a senior scientist from Economics, a post-doctoral fellow and five research students. Although the work is headquartered at IRRI and is part of the IRRI core programme, most of the research is carried out in irrigation project areas in collaboration with national institutions. In the Philippines, a close relationship exists with the National Irrigation Authority (NIA). Large scale irrigation facilities of the type used in production areas are not available at IRRI and consequently off-campus studies are necessary. Indeed, IRRI considers the Philippines as its primary laboratory for research and training in irrigation water management. The work in Indonesia and Bangladesh will expand the research opportunities.

**Main Achievements**

172. The programme is organized to provide a multidisciplinary approach to the study of irrigation systems. Progress has been made in the programme although the gains in this type of research are necessarily slow because of the lack of a proven methodology. Methodology has been developed to study irrigation systems, to provide a basis for problem identification and analysis, and to design research strategies to solve real world problems of existing irrigation systems. This methodology also provides the central framework and focus for the training programme.
173. Through collaboration with national irrigation agencies, water distribution problems typical of irrigation systems of various types and sizes have been characterized. Pilot field studies in two irrigation systems have shown that significant correction of inequitable water distribution to farmers can be achieved by modifying operational procedures for water allocation. Inequitable distribution causes serious problems of delay in water supply with too much water in some fields, too little in others, and drainage problems for the lower lying fields. A project in a diversion-type irrigation system used a reallocation procedure in which the tail-end farmers received water first while farmers at the head of the supply ditch received water last during the week; with this modification in water allocation tail-end farmers were no longer deprived of an early and adequate share of water. An on-site inspection in Central Luzon showed the value of this system although such an arrangement is difficult to maintain without farmers' understanding and cooperation. In another irrigation system with a reservoir, a concept of measurement-control-monitoring in the weekly delivery of water was based on estimated requirements, adjusted according to field observations. Again rice yields were improved, notably on tail-end farms, and tail-end farmers over a three-year period produced more than farmers near the head or middle of the system. With the better supply of water, tail-end farmers obtained higher rice yields at no disadvantage to farmers at the head and also began practising double cropping of rice and vegetables. IRRI's close association with NIA should facilitate the adoption of these improved distribution methods.

174. Techniques and equipment have been developed for quantifying the controlling variables that are critical in water related problems of irrigation systems. These include:

(i) simple predictive models for estimation of rice yield with water status and nitrogen use as inputs;

(ii) water flow measuring and control devices that are practical, inexpensive and easy to operate; and

(iii) practical procedures for estimation of water use in relation with seepage and percolation, and determination of effective rainfall in the field.

175. An annual six-week training course for irrigation system managers, designers, planners, and water management researchers was begun in 1977, (ref.para.398 ). During the period 1977-81, 101 participants from nine countries have been trained.

Constraints and Future Plans

176. Among the constraints of the Irrigation and Water Management Programme is the need for additional knowledge of practical methods for improving the operation of the various irrigation systems. There is
also need of a fuller understanding of the effect of increased farmer participation on the functioning of the system.

177. Adequate practical criteria for the design of irrigation facilities for effective water scheduling, delivery and distribution among users within turnout service areas of different types of systems are still not perfected. Not enough is known of the benefits and costs of different methods of irrigation water management. A serious constraint is inadequate understanding of the drainage problems in irrigation areas and the most effective method of dealing with these problems.

178. The plans for the next five years in Irrigation Water Management will continue to be made and implemented in collaboration with the concerned national agencies. Research in the Philippines will continue to focus mostly on the development of methodologies that will have wider applicability. During this five-year period collaborative research will be conducted in Bangladesh and Indonesia.

179. Specific plans for the 1982-87 period are as follows:

a) Reservoir system management studies in Central Luzon - to determine the most suitable method of irrigation system management for large areas irrigated from reservoir storage. This research is based on the findings of the IRRI-NIA joint research conducted in the Lower Talavera River Irrigation System during 1977-80.

b) Pump system management study in Bicol - to develop an efficient and practically useful operational procedure for large pump systems for rice irrigation.

c) Farmer organization study - to gain better understanding of the socio-institutional factors that influence or motivate farmers to organize sharing of irrigation water more equitably and to take greater responsibility in the operation and maintenance of irrigation facilities.

d) Economic studies - to evaluate the benefits and costs of different types and scales of irrigation development, of system management improvement schemes, and of alternative means for effective allocation and distribution of irrigation water.

e) Water use and rice yield studies - to evaluate the water use and rice yield relationship with various intensities of land preparation, and to assess field drainage requirements for high rice yields.

f) Bangladesh water management study - to develop effective methods of improving allocation and distribution of irrigation water and test the effects of optimum levels of soil, water and crop management on yields. The project was initiated in 1981 based on a memorandum of understanding between IRRI, Bangladesh Rice Research Institute and Bangladesh Water
Development Board.

g) Indonesia water management study - to increase the production of rice and other crops through better use of available irrigation water and increased cropping intensity and to study the constraints to high yields in selected Sederhana (small scale) irrigation systems. This collaborative research has been planned in 1981 through a memorandum of agreement between IRRI and AARD, Indonesia. IRRI's Multiple Cropping and Agricultural Economics departments are collaborating with Irrigation Water Management Department in this project which is expected to start in 1982.

h) Training course - the six-week irrigation water management training course will continue to be conducted once a year with the purpose of developing in the collaborating national agencies, a core group of personnel knowledgeable in the relevant concepts and procedures for efficient management of irrigation water.

Discussion of Priorities, Future Plans

180. The research programme on Irrigation Water Management outlined by IRRI for the next five years is well designed when assessed in terms of farmer needs and realistic research opportunities. The farmer needs assistance in obtaining effective and equitable distribution of water from existing irrigation systems, and these systems provide the IRRI investigators with the best facilities for their investigations. Such investigations are sometimes limited in scope by the difficulty of obtaining statistically valid comparisons but they are "real world" studies with results that can have immediate application. The general research approach successfully used in this programme for the past few years should be continued.

181. Although irrigation system management should continue to receive top priority, controlled studies of water use efficiency and soil-water-plant relationships need to be established. There may be ways that irrigation management can be used to improve the efficiency of nitrogen fertilization, which is a major yield limiting problem. Such studies can be carried out effectively only with the assistance of soil and crop specialists.

182. While increasing the overall production of rice, the development of a large scale irrigation system creates problems that either did not exist or were manageable before establishment of the system. One of the major problems is the flooding of large areas of the lower lying parts of the irrigation basin during irrigation. This condition is not to be confused with the inequitable distribution of water from a lateral canal supplying a single irrigation unit. The flooding problem is especially serious in Central Luzon. Some areas where formerly one good crop of rice could be grown during the wet season are now so wet from wet season irrigation water flooding that only a dry season crop can be grown. In addition, many less severe drainage conditions disrupt
planting and harvesting operations and adversely affect yields. The programme proposes to address the problem of drainage and the Panel recommends that as much research input as IRRI can afford be given to it.

Conclusions and Recommendations

183. The Panel recommends that this important programme should be continued at approximately the same level of effort. Rice is highly dependent on a timely and adequate water supply, and IRRI's management approach to improved water use can help to provide additional increases in rice yields. If the opportunity exists, cooperative basic studies on water use efficiency and the interaction of irrigation practices with other cultural practices should be expanded.

184. The programme is commended for its progress in studying problems on which there is a long standing interest on the part of national and international agencies involved in irrigation water development. Improvements in the efficiency of irrigation systems provide not only the direct benefits of improved water delivery but also increase the opportunities for wider adoption and increased effectiveness of the other aspects of modern rice technology. This relatively small programme thus has the potential for a definite impact, both directly and indirectly, on future rice production. The programme is also commended for its effective collaborative research activities with national programmes. The training programme should provide a new cadre of irrigation specialists trained to deal with the wide range of irrigation and water management problems in South and Southeast Asia.

(d) Soil and Crop Management

Background

185. Much of the work on soil and crop management is centred in the Departments of Agronomy, Soil Chemistry, and Soil Microbiology, and has been marked by a continuity of purpose that has not been too rigid to permit incorporation of worthwhile new research objectives. The Soil and Crop Management Programme is one of the most stable programmes at IRRI with the two senior scientists in soil chemistry and agronomy having been appointed soon after the establishment of the Institute. The Soil Microbiology Department at IRRI has also experienced few changes in leadership and programme objectives. Over the years the work in soil chemistry has progressed from basic studies of the physico-chemical processes taking place in flooded soils to more recent studies of varietal response to adverse and toxic soil conditions. The programme in agronomy has dealt with NPK fertilization trials of important varieties, weed control, tillage and crop management experiments, and fertilizer efficiency studies. The Soil Microbiology Department has concentrated on N transformation studies with major emphasis in recent years on biological N fixation.

186. Although there are few permanent senior scientists involved in these programmes, the research problems have been of such widespread
interest that a large number of visiting scientists, including a number of scientists with top international reputations, as well as a large number of pre- and post-doctoral assistants, have helped to carry out the programmes of the departments. The Agronomy Department has been especially successful in attracting both visiting scientists and international programmes.


Objectives

188. The major objective of IRRI's research on soil and crop management is to ensure that the most efficient production practices for the new plant varieties are identified. Studies on soil characterization, crop management, and crop nutrition are involved. In the coming decade particular attention will be given to the efficient formulation and methods of application of fertilizers, to the use of organic manures and to the contribution which biological nitrogen fixation can make to rice production. Basic to a proper understanding of how to manage the soil for rice production is an adequate characterization of soil properties, particularly those related to drainage and nutrient supply and the presence of toxic substances. It has been possible for IRRI to attract outstanding soil scientists to work on this topic, and it is expected that it will be possible to continue these arrangements.

189. Nitrogen supply is the most common factor limiting rice yield. Nitrogen fertilizers are a major cost in producing rice. In collaboration with IFDC, IRRI will maintain a programme of studies on the efficiency of use of applied nitrogen by rice crops, giving increased attention to the problems of rainfed areas. Factors controlling efficiency of recovery, and testing of new formulations of nitrogen fertilizers, will be an important part of the programme. Screening of rice varieties for their ability to utilize nitrogen more efficiently will continue. The present and potential contribution to the nitrogen nutrition of the rice crop by biological nitrogen fixation will continue to be studied, giving particular attention to the roles of Azolla and blue green algae and associative nitrogen fixation. Contributions from legumes grown in association with or in succession to rice will receive some attention.

190. The role of organic manures in rice production will receive increased attention in the next decade. Adverse effects associated with the use of organic manures on rice paddies have sometimes been recorded, and they are much less widely used in tropical rice production than in subtropical and temperate areas. Collaborative studies on basic factors relating to organic matter mineralization will be pursued, as well as field studies of yield responses to organic materials utilized in different ways. Particular attention will be given to the use of organic
manures on less advantaged areas where use of fertilizers is uneconomic. Studies on the importance of nutrients other than NPK will also be continued, particularly of zinc and sulphur, whose special importance for paddy rice production has now been established; they have been somewhat neglected in previous studies.

191. Another responsibility of the Soil and Crop Management Programme is the International Network on Soil Fertility and Fertilizer Evaluation for Rice (INSFFER). IRRI will continue to coordinate the network, in collaboration with IFDC. Collaborative testing of new fertilizer formulations will continue, giving increased attention to soil and climatic factors which determine success and failure of different formulations in different locations. Greater emphasis will be given to collaborative studies on the role of Azolla and other organic manures. Site visits, regional workshops, and planning meetings will form an increasingly important part of INSFFER activities.

192. Rice crop cultural practices will continue to be studied as necessary, particularly for rainfed systems. Tillage methods and management of soil physical conditions will be studied, particularly in relation to the use of organic manures, and also weed control and crop establishment in rainfed conditions. Puddling and restructuring of puddled soils for a dryland crop grown after wetland rice is a process peculiar to paddy rice production, and of major importance in rice-based cropping systems. This subject has been largely neglected. The appointment of a soil physicist to the IRRI staff would provide an opportunity to advance in this area.

Means - Personnel, Facilities

193. Nine senior staff members are listed as participating in the Soil and Crop Management Programme, four from the above mentioned departments, the others from cooperating departments. Excellent laboratory, greenhouse and field facilities are available for the programme, with most of the activities located at the Institute. In earlier years, the degree of sophistication of the instrumentation was somewhat low, largely because of maintenance problems, but in recent years facilities such as a phytotron, a mass spectrometer for stable isotope work, and radioisotope facilities have been acquired. Some of the research, especially that involving Agronomy Department personnel, is carried out at other sites in the Philippines. One programme (INSFFER) has activities in 18 countries.

Main Achievements, Constraints and Future Plans

194. IRRI's work in soil and crop management has generally kept pace with the Institute's outstanding achievements in the areas of plant breeding, germplasm work, and plant protection. A brief description is given of the major findings in each of the research programmes, followed by a discussion of major constraints and future plans.
195. **Land Characterization:** Nutrient deficiencies, soil toxic conditions and other adverse soil conditions have been identified and evaluated for a large number of soils from South and Southeast Asia. Some success has been obtained in developing reasonable treatments for some of these conditions, most of which are difficult to deal with in an economical way. Boron toxicity was identified as a growth limiting factor on rice soils irrigated with deep well or geothermal water. The relationship between zinc deficiency and high water soluble silicon was also established. A better understanding was obtained of the chemical processes in coastal saline soils which influence rice growth.

196. GEU utilizes the information gained in this programme to evaluate breeding lines and cultivars for adverse soils tolerance. Mass screening methods have been developed and used for various toxicities and deficiencies. This work has identified breeding material tolerant for salinity, alkalinity, iron toxicity and acid sulfate soils. Varieties such as IR36 and IR42 have been found to be tolerant to multiple soil stresses. The genetic control of salt tolerance and zinc stress has also been demonstrated.

197. One of the major constraints is the serious lack of information on the geographical distribution of soils with toxic and other adverse soil conditions. It is encouraging to note that plans are underway to develop cooperative research with national and international agencies on characterizing and delineating toxic and nutrient deficient rice soil areas. Although the general nature of micronutrient deficiency is known, there is, in most parts of Asia, insufficient information on the yield response that can be obtained by addition of these elements. It is hoped that the cooperative research effort will provide some information on this problem.

198. Because of widespread occurrence of problem soils and their potential role in rice production, additional basic information is needed on the nature of the effect of certain soil toxicants on the rice plant. Such information would be worthwhile to the rice breeder in selecting tolerant lines. It was revealed during the review that rice varieties vary in their ability to produce on zinc deficient soils even without any selection pressure for low zinc tolerance. This will make it worthwhile for GEU to continue to develop lines that are adapted to zinc deficient soils. Basic work from the Soil Chemistry Department that will help to identify the relative roles of nutrient deficiency and soil toxicity should be continued. Recent research work reported from Vietnam indicates that acceptable rice yields can be grown on acid sulfate soils in the Mekong delta by using a unique farmer-devised water control system that provides enough drainage for necessary crop management practices without producing enough acidity to release toxic amounts of iron. It might be worthwhile to initiate a research project on possible new management techniques for acid sulfate soils in addition to the chemical treatments that have been devised.
199. Management of Soil and Fertilizer Nitrogen: A better insight into the mechanism of loss of urea nitrogen is being obtained using various measurement techniques. Management practices for the use of nitrogen fertilizer will be influenced by the results of this study. Tracer studies of other nitrogen transformation showed the distribution pattern of ammonia after placement at different depths and confirmed the greater N conservation obtained from deep placement. Field studies demonstrated the superiority of slow release nitrogen material and large pellet material (supergranules) over regular urea.

200. This research project is extremely active with one of the experiments involving IRRI, IFDC and CSIRO personnel cooperating in the comprehensive evaluation of gaseous loss of fertilizer urea nitrogen from the soil. An improvement in the utilization of fertilizer nitrogen would have a significant effect on rice yields since the potential yield with a moderate application of nitrogen fertilizer is much higher than the actual yield obtained. Although the development of proper placement techniques and special machinery will help in achieving this goal, economic constraints of the small Asian farmer favour the development of a more efficient nitrogen material that can be applied in traditional ways. In addition to improving the efficiency of nitrogen fertilizer use, the continual release of new varieties makes it imperative to know their nitrogen responsiveness; this is part of the CEU programme.

Nitrogen Fixation for Paddy Rice, and Management of Organic Manures

201. These projects have provided information on the practical role of biological nitrogen fixation in a rice cropping system. Of the three mechanisms of nitrogen fixation studied, fixation by the Azolla/Anabaena complex and associative nitrogen fixation by heterotrophic bacterial living in association with rice roots appear to have the most promise on the soils at IRRI. Grain yield with Azolla alone was equivalent to that obtained from 70 kg N/ha. Associative nitrogen fixation accounted for approximately 50 kg N/ha per crop of rice. Although neither method shows promise of completely replacing fertilizer nitrogen, they do show promise for decreasing fertilizer nitrogen requirements. Plans are underway to select for varieties that show a high associative nitrogen fixation capacity.

202. A detailed study of the other nitrogen fixing organisms, blue green algae, showed a high rate of predation by insects under IRRI soil conditions. Predation limits nitrogen contribution of blue green algae although they have been effective in other environments. Depression of algal predators by natural and synthetic materials increased the nitrogen fixation. Labelled nitrogen studies showed that, as in all biologically fixed nitrogen, only a part of the nitrogen is released to the current crop and a significant portion of the remaining organic nitrogen is lost from the system before another crop is grown. Nevertheless, the high requirement of rice for nitrogen and the high cost of fertilizer nitrogen should stimulate research in this area for a long time to come. A comprehensive literature review on the role of blue
green algae in agriculture has been completed and published.

203. In addition to nitrogen fixation, research is conducted on the effect of organic matter, particularly residues, on rice cropping practices. Although many studies of this nature have been done since early in the century, the larger supplies of residue being turned under in modern cropping systems call for a modest investigation of the problems of toxicity, decomposition rates and products, and interaction with other nutrients.

204. Management of Other Nutrients. Nitrogen is the nutrient most widely deficient in rice culture and large responses are almost always obtained with its application, compared to the addition of phosphorus, potassium, zinc and sulfur unless these other nutrients are extremely deficient. Nonetheless, profitable yields of rice cannot be produced in many areas of South and Southeast Asia without adding more nutrients. An increasing need for additional nutrients occurs when a high level of management results in higher yields and increased nutrient withdrawals from the soil. The development of low cost techniques to correct zinc deficiency and the use of crop residues to increase the supply of available phosphorus and potassium are among the achievements of this project that may have immediate application. Continued work should be done to identify and evaluate in field and laboratory studies various domestic sources of phosphate in Asia that would be much cheaper for the farmer to use. Rice has more capacity than most crops to utilize some unprocessed sources of phosphate. In these, and for that matter in all other studies of IRRI, concern should continue to be shown for the development of practices that have wide geographical application.

International Network on Soil Fertility and Fertilizer Evaluation for Rice (INSFFER)

205. INSFFER started in 1974 and now operates in 18 countries. A full-time Network Coordinator is supported by special funding from the Swiss Government, but IRRI is requesting that the Coordinator’s position be made a part of the core programme. The International Fertilizer Development Centre (IFDC) cooperates with IRRI and the national programmes in the network. IFDC provides technical support and fertilizer materials to be tested; IRRI provides technical coordination, data collection, analyses and reporting.

206. INSFFER provides an effective framework for collaborative research trials, training, and site visit tours for network scientists, and it is an effective mechanism for disseminating research results not only from IRRI to the national programmes, but in the other direction as well. Collaboration with IRRI economists has resulted in a questionnaire for farm-level economic data. This questionnaire will be used in the network to gather more information on economic aspects of fertilizer use and potential in collaborating countries.

207. Training has received much attention in the INSFFER programme. Since 1974, three four-month training courses have been held, with 64 trainees from 13 countries participating. Site visits were made to India
and China in 1980 and Bangladesh and India in 1981. Training is also
given to junior assistants of collaborators. Economic data on
fertilizer use are collected and used to work out alternatives to be
tested in the network. Future plans call for alternative local sources
of fertilizers to be included in the research trials. Site characterization
will be intensified. Long term trials will be set up to study residual
or long term gains or losses of fertility under different conditions.
Site visits will be continued, and a workshop will be included as a part
of each tour.

208. INSFFER is another example of the successful role IRRI has played
in bringing together scientific personnel from national programmes
INSFFER is also a good example of how two international centres can work
together effectively. IRRI should continue to support this cooperative
project with the national programmes and with IFDC.

Rice Crop Cultural Practices, and Tillage and Management of
Soil Physical Conditions

209. These two programmes cover research on the agronomic and soil
physical aspects of various cultural practices used for rice. Important
results have been obtained from the work on cultural practices. The use
of early maturing rices and direct seeding have been established as an
effective practice for obtaining an additional rice crop in many areas.
Continuing studies provide refinement of management practices by
manipulating seedling age, plant density and fertilizer usage to obtain
maximum yields of rice.

210. There are studies that must be continued in the research programme
to take advantage of new techniques and materials so that cultural
practices can be continually updated. The rapid change in rice cropping
practices brought on by short season varieties and the availability of
increased water supplies require the development of new and improved
cultural practices.

211. Soil physics studies have not received much attention at IRRI.
The traditional view that puddling the soil disrupted the physical
condition of the soil to the point that studies on structure, aggregation,
unsaturated moisture movement, and soil aeration were unnecessary has
undoubtedly contributed to keeping this a low priority. The unavailability
of qualified scientists in this highly specialized field has also been a
factor. Adverse soil conditions are now being recognized at IRRI and at
other locations that appear to be at least partly related to the physical
properties of the soil, and the Institute has responded by requesting
employment of a soil physicist for several years. In addition to the
need for characterizing and studying the physical environment of the
plant-soil water system, several other programmes could profit from
cooperation of a soil physicist. Although the Agronomy Department has
met part of this need with studies on tillage practices, moisture
utilization and internal drainage, adequate understanding of these
and other soil physical conditions in flooded rice soils await the
establishment of a more focussed programme.
Conclusions and Recommendations

212. No special case needs to be made for a strong programme in soil and crop management at a mission-oriented crop research centre. Understanding soil conditions, nutrient availability, and chemical, physical and microbial processes that affect plant growth and crop yield is essential. IRRI has one of the strongest programmes in this field among the IARCs, and the addition of an effective soil physicist would give added strength. The last quinquennial review also recommended strengthening of the soil physics work. The programme has a number of untapped research opportunities as discussed above, but no convincing argument can be made for serious weaknesses in the programme. Some aspects of the programme serve as a world crossroads for the evaluation of new and sometimes controversial ideas about rice-flooded soil systems which lend some excitement (at least among the initiated) to the programme at IRRI.

213. The soils and agronomy programmes at IRRI have also developed a solid scientific reputation by presentation of papers at international meetings and especially by significant publications in the scientific literature. Of particular note has been the writing of a book by one of the staff members that is likely to be the standard text on principles of rice production for years to come. The maintenance of this reputation should be of great interest to all the scientists in this programme.

214. The Panel recommends that the programme on Soil and Crop Management be maintained at approximately the same level in Soil Chemistry, Agronomy, and Soil Microbiology and that a high priority be given to the establishment of an effective soil physics programme. With the request to IRRI for work with rice cropping systems other than irrigated rice, consideration should be given to soils research that deals with problems of rainfed rice and upland rice.

(e) Environment and its Influence

Environmental Characterization and Assessment

215. The influence of environment has recently become of more concern to rice scientists. In part this is due to the increasing attention being given to types of rice culture other than irrigated rice, but other factors, such as the need to understand better the response of rice to problem environments are also involved.

216. The foreword in the IRRI book Climate and Rice describes the situation very well: "Rice is grown under more diverse environmental conditions than any other major food crop in the world. Rice originated in the hot, humid tropics where monsoon rains and flood-waters create an aquatic environment for at least part of the year. Rice has adapted within a broad latitude - as far north as Hokkaido in Japan and south to Australia. Rice is cultivated in the cool climates of the high altitude
areas of Nepal and India, as well as in the hot, dry climate which characterizes Egypt, southern Pakistan, and Iran. In Africa, Latin America, and parts of Asia, rice is grown as an upland crop subject to frequent droughts. At the other extreme, "floating rices" thrive in the annual flood water three meters or more deep in parts of Thailand, Bangladesh, Burma and Vietnam.

Within the wide range of conditions in which rice is grown, the crop is exposed to a wide array of temperature, rainfall, soil and seasonal conditions. Many of these environmental factors are so extreme as to cause severe injury and crop loss. Some are so anomalous that they almost defy rational solution. For example, in some fields of deepwater or floating rice the crop in the seedling stage may be subject to severe drought, followed by a flooding period when rapid elongation and tolerance to submergence become factors in crop survival. Other important environmental factors determining rice performance and yield include amount and pattern of solar radiation; air and water temperatures during the crop cycle; length and reliability of the rainy season; soil and land capabilities, including fertility and possible toxic factors; and so on.

Increasingly, rice production is expanding into less desirable marginal lands. For many countries such lands represent the only hope for expansion and/or intensification of agriculture.

IRRI Activities in Environmental Characterization and Classification

Rice scientists are keenly aware of a need to characterize and classify physical environments in which rice is grown. Necessarily, many of these efforts have started first with a study of climate and soils. IRRI has also started in this way, attempting to understand major factors and resources in the environment first before going on to a classification that synthesizes climate, land and other physical factors into a comprehensive classification for rice environments and land systems.

Several major workshops have been held at IRRI to determine what is known in particular fields and to define priorities for research and collaboration. All of these have resulted in major state-of-the-knowledge books; e.g., "Agrometeorology of the Rice Crop", "Climate and Rice" and "Soils and Rice". Another book, "Rice: Soil, Water, Land", was prepared by two visiting scientists and published by IRRI.

Several programmes at IRRI emphasize characterization and/or classification of environmental factors for rice. A system for classifying rice production systems has been worked out that provides a basis for communication between, and a research framework for, agronomists, breeders, crop protection scientists, soils and water scientists, and economists. The classes are: (i) irrigated and rained, shallow, favourable; (ii) dry-land and rained, shallow, drought prone; (iii) rained, medium deep, waterlogged (25-50 cm); (iv) rained, deepwater (50-100 cm) and floating (> 100 cm); (v) rained, shallow, drought and submergence prone; (vi) rained, shallow, submergence prone; (vii) rained, medium deep, tidal swamp or shallow, acid sulphate. CEU uses this classification in its search for
germplasm suited to differing ecological conditions, including drought tolerance, tolerance to adverse soils, deepwater and flood tolerance, and tolerance to adverse temperatures. Also, the IRTP uses the concept of environmental stratification in its problem-oriented network of nurseries.

222. Land characterization studies are carried out by a team of soil scientists and agronomists. The purpose is to characterize chemical, physical, and microbiological soil constraints on productivity of rice. The work includes identification of areas with major soil constraints.

223. A programme to characterize the climatic environment for rice is carried out collaboratively between Cropping Systems and the IRTP. The purpose is to characterize agroclimates for rice production in the humid tropics. A new cooperative rice–weather research programme between WMO and IRRI will begin this year.

224. The Physiology Department has a programme on rice response to environment. The main objective is to provide a better understanding of how environment affects growth and yield of rice, and of the physiological principles that govern the response of rice under different conditions.

225. Cropping Systems has a programme on analysis of the physical and biological environment. The project was initiated to provide information for Cropping Systems research, but it could form the basis for strengthening other research activities on land and climatic factors. Much new information has been gained about the physical environment in which the small Asian farmer operates. Maps showing the expected duration (in months) of wet and dry periods were developed for the Philippines, and parts of Indonesia, Bangladesh, Burma and Thailand. A preliminary land classification system has been developed. The system is based on climatic and soil/land characteristics.

226. To have a consistent measure of rice lands and their characteristics, and to provide a basis for delineation and description of potential target areas, some classification of rice land must be adopted. Such a classification should be based on a synthesis of the three dominant physical factors, temperature, soil conditions, and water conditions. No existing data classify the world's rice lands by these three criteria. The Panel suggests that this work should be approached in a comprehensive, coordinated way. IRRI might wish to consider ways in which environmental characterization, classification and perhaps management could be linked in a multidisciplinary way, such as in the GEU programme.

227. More details on specific programmes will be presented in the respective sections of this report.

Climatic Influence
Background and Objectives

228. After succeeding in breeding a variety with strikingly high yield potential, IR8, by improving plant type, IRRI's emphasis gradually shifted
to research aiming at stabilizing the yield by providing resistance or tolerance for biotic, physiological and climatic stresses. Thus, it aimed in this study to determine the optimum plant characteristics to utilize solar radiation fully, while tolerating stresses due to extreme temperatures, adverse factors in the root environment, etc. Because world food demand is still rapidly increasing, IRRI needs to test several new possibilities to further increase the yield potential by enlarging the "sink size" or by controlling the senescence of leaves of material it has developed. IRRI divides environmental research into three areas: characterizing climatic environment for rice; rice response to environment; and climate and rice production.

229. A phytotron containing ten growth cabinets (KOITO KG-Type) was built at IRRI in 1974. However, at present all growth cabinets are operated at 25°C, to grow experimental materials, mainly seed production, as there is a shortage of insect-free greenhouse facilities. A screenhouse is needed to allow the phytotron to be used for its original and appropriate objective (ref. para. 471).

Main Achievements

230. Effect of solar radiation and temperature: Based on the data collected from 26 locations in 15 rice-growing countries, an equation was obtained to estimate dry matter accumulated per m² of field. The equation indicated that dry matter accumulated in proportion both to the effective length of the grain-filling period and to the average solar radiation during that period. By phytotron experiments it was shown that the spikelet number per m², one of the most important factors determining the assimilate-storing capacity of rice, was closely and positively correlated with average solar radiation and negatively correlated with mean daily temperature during the reproductive stage. Based on these and other data a simple simulation model, RICEMOD, was developed to estimate rice yields in well-watered, well-fertilized fields from solar radiation, temperature and day length. The results of weather data computation at Los Baños during the grain-filling period agreed very well with the experimental yields using IR36, as long as disease, pests and rat damage were not serious.

231. Adaptation to climate: It was found that in tropical rice both active growth period and grain-filling period are considerably shortened due to high temperatures, thereby reducing grain yield, as compared with temperate rice in its own environment. In experiments located at four sites between 14° N and 37° N the performance of three indica/japonica crosses was shown to be more stable, while their low temperature tolerance was lower than those of a japonica, Jinheung, and an indica, Lenkwang. The low temperature tolerance could be considerably improved by potassium supply, but was diminished by nitrogen supply.

232. Anaerobic root environment: Release of molecular oxygen from rice roots into the rhizosphere was examined as a possible means of counteracting the adverse anaerobic soil conditions. It was found that:
(1) oxygen was transported from shoot to root mostly as molecular oxygen, $O_2$, with little enzymetic transport, (2) up to $30^\circ C$, $O_2$ release was observed, but at $35^\circ C$ no $O_2$ was observed due to increased root respiration, (3) root growth was impaired under low partial oxygen pressure. Seed coating with calcium peroxide was effective to improve seedling emergence from flooded soil, suggesting the importance of drainage.

**Constraints and Future Plans**

233. For these basic studies to be continued, not only close collaboration with scientists in developed countries, but also better trained research assistants, postdoctoral fellows, research assistants, research fellows and sustained support are needed.

234. Genetic manipulation of spikelet number and grain size will be pursued to increase "sink size" and means will be studied to decrease maintenance respiration or photorespiration with the aim to reduce assimilate losses. Efforts will be made to find factors controlling the process of senescence of leaves and grains.

235. Climatic studies are scheduled to be undertaken in collaboration with WMO to analyse responses of rice to various climatic conditions by using the IRTP data. Effective feedback to further physiological studies is expected.

236. Rapid generation of materials through tissue culture will be used to introduce rapid screening for the identification of tolerance materials.

**Discussion of Priorities**

237. Substantial and high quality basic work has been done in this programme with one professional core staff member. Great contributions have been made by visiting scientists and postdoctoral fellows. However, the interaction between solar radiation and temperature needs more detailed study as does the sink-source relationship in the yield formation of rice.

238. The Panel recognizes that a certain amount of research of a more basic nature is always necessary for any research institute to maintain its creative activity. The present study fully qualifies because of its innovative nature. Its achievements, when available, are expected to be most useful for exploiting new types of varieties.

239. Obviously, IRRI has concentrated most of its resources to improve high technology for irrigated conditions, especially under Asian conditions. Fortunately, the high input technology for irrigated rice has had a fairly successful spill-over effect to Africa and Latin America. The varieties have in most cases done well also under rainfed lowland conditions of Asia which constitute about 50% of the total rice area. Therefore, IRRI now should direct its resources more to the study of these and other less favourable environments.
Conclusion

240. The Panel considers it important that basic physiological research continues to be supported to help plant breeders raise the yield potential of rice varieties.

Drought Resistance

Background and Objectives

241. Dryland rice, occupying 19.1 million ha of the world rice area, and rainfed shallow rice, occupying 29.7 million ha, are both subject to variable drought. Thus, the development of drought-resistant rice varieties is badly needed. In order to identify and use drought-resistant mechanisms in breeding, a basic knowledge of the response of rice plants to water stress must be acquired over a broad spectrum of environmental conditions. Therefore, the following objectives have been formulated:

a) To achieve a better understanding of the physiological basis of drought escape, avoidance, tolerance, and recovery in relation to varietal difference.

b) To devise techniques for a quick identification of the different components of drought resistance and to utilize these in screening techniques to evaluate the elite breeding lines and accessions of the germplasm bank.

c) To develop a full spectrum of genetic materials which combine as many drought-resisting components as feasible.

Means - Personnel, Facilities, Sites

242. A full-time agronomist and five senior staff of different departments work on drought resistance. Evaluation of varieties is done through the IRTP, and collaborative work is underway with the Philippines, Thailand, Indonesia and India.

Main Achievements

243. Out of over 50,000 cultivars, breeding lines and germplasm accessions, 4.4% were found to be drought-resistant. Four genotypes and two varieties were found to be drought-resistant in collaborative, multilocational yield tests in the Philippines and in Thailand. Collaborative work with the USA and UK has clarified the role of abscisic acid and osmotic adjustment in the response of rice plants to drought. Close correlation was found between the morphology of the root system of the rice plant and drought resistance or recovery ability. On acid dryland soils similarity to drought damage is being related to aluminium toxicity in these soils. Installation of an aeroponic culture system facilitated genetic studies of root morphology.
Constraints and Future Plans

244. Occurrence of various abnormalities in the progenies of semi-
dwarf and dryland crosses, the rarity of resistance in the reproductive
phase, and the existence of a negative correlation between depth rooting
and recovery ability are the main constraints. IRRI's fields with their
frequent rainfall and fertile soils are another constraint for drought
experiments. Therefore, a new site in the Philippines with a relatively
dry growing season will be sought to facilitate large scale screening in
the field. Incorporation of drought resistance into elite lines is to be
continued, and materials are to be evaluated on sites in Asia, Africa,
and Latin America through special collaborative arrangements as part
of the research in upland rice. Work on the characterization of rainfed
and dryland environments for rice will be facilitated by filling the
existing soil physics position, and the appointment of an agro-
meteorologist under a special grant.

Discussion of Priorities

245. Based on the results of various physiological and agronomical
experiments conducted so far, a plant type thought to be most suitable
for drought-prone areas has been tentatively proposed. There are some
contradictions among the component characters. Information is lacking
about the most important character(s) regarding the capacity of the
plant to regulate the water content of the tissue and to continue growth
under water-stress conditions. Assuming IRRI intends to emphasize
research on rainfed rice, basic but difficult research in this direction
is needed.

Conclusions

246. Priority should be given to the selection of an experimental
site more suitable than the IRRI farm for mass field selection work.
Better use of IRTP data and the feedback thereof to basic breeding
studies should be encouraged. More efforts should be made toward
identifying character(s) with respect of the capacity of the rice plant
to maintain its water balance and to continue root growth under water-
stressed conditions.

Adverse Soils Tolerance

Background and Objective

247. In South and Southeast Asia, millions of ha of land apparently
suitable to rice cropping lie idle, largely because of soil problems,
such as salinity, alkalinity, strong acidity, and excess organic matter.
On millions of ha of cultivated lands, rice yields are limited by soil
toxicities and nutrient deficiencies.

248. The objective of this study is to identify and define the major
soil problems, to develop mass screening methods for tolerant genotypes,
to identify sources of tolerance, and to breed tolerant varieties as well as to do relevant basic research.

Means - Personnel, Facilities, Sites

249. Cooperative work is underway at 14 locations in the Philippines and in the UK. Variety tests are carried out through the IRTP for Adverse Soil Tolerance.

Main Achievements

250. Two kinds of yield-limiting soil factors, soil toxicities and nutrient deficiencies, were identified. The former includes salinity, alkalinity, acid sulfate soil, peat soil, and toxicities of iron, aluminium, manganese, and boron, and the latter includes nitrogen, phosphorus, sulfur, zinc and iron. Mass screening methods were developed for some toxicities and deficiencies. Of all rice accessions from the world collection and IRRI's breeding programmes, one sixth was found to be tolerant to some form of soil stress, and 41 rices were identified as usable breeding material tolerant for salinity, alkalinity, iron toxicity and acid sulfate soil. Some IR varieties, such as IR36 and IR42 were found to have tolerance for multiple soil stresses. Genetic control was demonstrated in salt tolerance and zinc stress. Tissue culture in combination with chemical mutation as a rapid screening method was suggested.

Constraints and Future Plans

251. Constraints are the lack of a screening method for single plant evaluation, absence of material having a high tolerance for salinity and alkalinity, the unsuitability of modern varieties for soil stresses in areas subject to deep flooding, and insufficient knowledge on the genetic and physiological mechanisms of tolerance for mineral stresses. Insufficient international testing of rices found to be tolerant for soil stresses in the Philippines is another constraint. In the future, primary attention is to be directed to studies of salinity tolerance. Tissue culture methods will be explored for rapid identification of lines with a high degree of tolerance. Efforts will be made to combine salt tolerance with other characters, such as adaptation to tidal swamp conditions. Tolerance for iron, zinc and phosphorus deficiency will be sought and incorporated into breeding lines with other desirable characters. Basic studies on the biochemical, physiological, and genetic aspects of tolerance for adverse soil problems are also scheduled.

Priorities

252. The same situation exists in this programme as the one observed in drought resistance research, as a result of a shift in priority from basic to more applied studies in the second decade, IRRI has gradually reduced its capacity to develop new experimental technology. Without simple, but reliable, methods based on scientific evidence, no mass selection and no efficient breeding are possible. The introduction of
tissue culture may be one of the counter measures. However, there are also many other possibilities. The Panel suggests that slightly higher priority be given to studies on physiological responses of rice plants to various toxicities and deficiencies, in relation to variety, growth stage, and environments.

253. On the other hand, under circumstances where there are no simple effective methods other than on-the-spot selection, collaboration with national programmes may be more important.

Recommendation

254. To define the tolerance of rice plants to various problem soils and to develop screening methods, the Panel recommends an increased emphasis on basic research in the physiological and genetic aspects of tolerance to problem soils. Collaboration with national programmes should be encouraged.

Deep Water and Flood Tolerance

Background and Objective

255. There are approximately 12 to 13 million ha of low-lying lands in the world where water depth may vary between 30 and 100 cm during at least part of the growing season. In addition, there are about seven million ha of tidal swamp area. These areas occur in India, Bangladesh, Burma, Thailand and Vietnam. Duration of deep-water may vary from two to five months, sometimes completely submerging the rice plants. Water regime and other conditions differ not only from place to place, but also from year to year, making the solution of the problem even more difficult. In 1974 cooperative work started between Thailand and IRRI, and practical field screening facilities were constructed near Bangkok. Since 1976 the International Deep-Water Observational Nursery (IRDWON) kits have been distributed.

256. The objectives of this programme are (i) to incorporate into high yielding varieties those plant characters necessary to withstand and adapt to the various flooding patterns and other conditions of deep-water regions; (ii) to establish cultural practices suitable to those regions, and (iii) to understand the physiological and agronomic bases of high grain yields in deep-water and floating rice.

257. Work on deep-water rice is carried out at the screening facility in Thailand and greenhouses at Los Baños. Varietal tests are done through the International Rice Deep-Water Observational Nursery.

Main Achievements

258. Two deep-water varieties (RD 17 and RD 19) were obtained by this programme in 1979. They are intermediate in plant height and have elongation ability. Crosses from IRRI’s Rapid Generation Advance Programme
were included in the 1980 IRDWON, and from these, two deep-water varieties (Yenet 1 and Yenet 2) were named and released in Burma, while India released two deep-water varieties (CN540 and CN643) obtained from the hybrids of the IRRI-Thai Programme.

Constraints and Future Plans

259. The flooding pattern and timing of rapid rise and fall of the water are so irregular and unpredictable that the degree of submergence tolerance and elongation ability, the two most important requirements in adapted cultivars, cannot be fixed. This requires not only the study of a wide range of materials but also the selection of quite different site specific targets. Other major constraints are: submergence tolerance seems to be linked with many undesirable characters although little is known of its inheritance; the number of experimental sites is too limited to represent various deep-water areas; there is a lack of knowledge of diseases and pests and of cultural practices.

260. Work on flood tolerance will include a better characterization of the environment where flooding and crop submergence are problems. Basic studies on mechanisms of tolerance to submergence and on factors controlling elongation ability will be initiated. The proposed future plan is considered to be adequate.

Discussion of Priorities

261. To overcome various difficulties arising from the great diversity of flooding patterns, there are three possible approaches. One is to set up highly site-specific breeding targets for each subregion as defined after a survey of the flooding patterns of the regions concerned. The second is close collaboration with national programmes so as to take into account site specificity. The third is to identify the physiological basis controlling the two most important characteristics concerned, submergence tolerance and elongation ability.

Adverse Temperature Tolerance

Background and Objective

262. An estimated seven million ha of rice growth in high altitude areas in the tropics are thought to be affected by low temperature problems. Low temperature can result in low yields through either growth retardation in the vegetative phase or sterility. On the other hand, in semi-arid tropical areas high temperature coupled with low air humidity can also cause low yields through sterility.

263. As to the low temperature problem, the objective of this study is to develop a screening technique for various characters related to cold tolerance, to identify sources of tolerance, and to incorporate cold tolerance into high-yielding varieties, along with resistance to
diseases prevalent in low temperature areas. As to the high temperature problem, the objective is to develop a screening technique for high temperature tolerance, screen the germplasm of IRRI and that of some problem areas for high temperature tolerance, and study the physiological mechanisms of high temperature-induced sterility.

Main Achievements

264. Low temperature tolerance: Screening for cold tolerance was carried out with various materials at IRRI and elsewhere collaboratively with the Philippines and Korea, which has suitable facilities at Chuncheon. Collaboration is also underway with USSR and China. From the International Rice Cold Tolerance Nursery formed in 1975, a cold tolerant variety RPKN-2 was released in the Philippines and Indonesia.

265. High temperature tolerance: The most sensitive stage for high temperature-induced sterility was found to be at anthesis. Temperatures of about 35°C for one-two hours at anthesis could induce sterility. Varietal difference was related to anther dehiscence caused by untimely elongation of the filaments and partly to loss of viability of pollen. A screening technique was established and some tolerant varieties were found.

Constraints and Future Plans

266. There is a shortage of trained personnel. As for the high temperature problem, lack of appropriate sites with a hot arid climate, available to IRRI, is an additional constraint.

267. Collaborative efforts with national programmes to identify cold tolerant varieties and efforts to combine cold tolerance with other desirable characteristics will continue. Particular attention should be given to blast resistance together with cold tolerance. New sites for collaborative work on screening for high temperature tolerance have been identified. Generation and testing of new breeding materials tolerant of high temperature will continue.

Discussion of Priorities

268. Screening for cold tolerance is now being done by treating rice plants with cold water throughout the whole growth duration, so that both the resistance to growth retardation and sterility are screened. For a more detailed classification of varieties, it will be necessary to add treatments given at different growth stages, as is already done in Japan. Northeastern Brazil could be one of the appropriate places to screen for high temperature tolerance.

Conclusion

269. Some achievements have been made on low temperature tolerance and high temperature tolerance, the former as a result of international
collaboration, and the latter as a result of typical physiological studies using the phytotron.

(f) Production Constraints and the Consequences of New Technology

Background and Objectives

270. The real disappointment to IRRI in early 1970 was that while rice scientists obtained yields of five to ten t/ha on the IRRI farm, many Asian farmers obtained, on average, only less than one t/ha increase in yield after adopting the high-yielding varieties. The constraints which prevent a farmer from obtaining higher yields can be economic, social, institutional, or due to the physical and biological environment of his farm. Another concern of IRRI scientists at that time was the growing criticism in the world about the question of who benefited from the introduction of the new rice varieties and the related technology. Agronomists, economists, agricultural engineers, and statisticians developed a multidisciplinary research project to study rice yield constraints and another project to study consequences of new technology.

271. The primary objectives of Constraints Research are to identify and measure three groups of factors which limit the performance of available new rice technology. They are:

- constraints to the adoption of new rice technology;
- constraints to the effective use of available rice technology;
- constraints due to existing biological, physical, institutional and socio-economic factors that limit the productivity of available rice technology.

272. The objectives of Consequences Research are as follows:

- to examine the effects of the introduction of new rice technologies on production, incomes, distribution of income, employment and social welfare;
- to identify the effects of ownership control over resources and product distribution systems on the consequences of new technology.

The results should also assist in evaluation of alternative methods for introducing new rice technologies, and/or in understanding the effects of new technologies so as to provide feedback to biological scientists and engineers on desirable performance and cost characteristics of technology.

Means - Personnel, Sites

273. There has been a great effort to strengthen economic research in IRRI, and the number of economists increased from five in 1975 (including those in the Machinery Department) to 10 in 1981 through the
addition of three economists supported by special projects. Constraints research and consequences research have remained static in that both have been confined mainly to the Philippines. A major effort has been made to obtain data at the farm level and the village level because accurate data collection is essential for these studies.

Main Achievements

274. **Constraints Research**: This programme is relatively new. The work to date has stressed the "yield gap" and a practical approach has been devised to define and measure the yield gap - the difference between actual yield from farmers' fields using modern technology and the yield the farmers could have obtained using modern technology to its full potential. The objective was to identify the factors or constraints which contribute to this yield gap, and to explain why the yield gap exists. This research approach was developed and documented in a "Handbook on the Methodology for an Integrated Experiment-Survey on Rice Yield Constraints" (1978). With support from IDRC the International Rice Agro-Economic Network (IRAEN) was established by IRRI in collaboration with constraints researchers in Bangladesh, Indonesia, Philippines, Sri Lanka, Taiwan and Thailand in 1975. More recently, constraints research has been initiated by MARDI in Malaysia, CRRRI, AICRIP and ICRISAT in India, and by rice researchers in Pakistan. IRRI economists act as advisors or collaborators in these projects.

275. Fertilizer and insect control practices accounted for most of the yield gap. It was profitable to increase the level of fertilizer used by farmers which is usually lower than what IRRI found to be profitable particularly in the dry season. The yield gap due to low fertilizer usage was significantly related to the ratio of fertilizer to rice prices. As a result of these studies, some countries in Asia changed their market price ratio of fertilizer to rice which resulted in a good increase in rice production. The yield increase due to improved insect control was variable among locations and years, and the costs of control were high. These findings have encouraged the development of integrated pest control at IRRI and elsewhere.

276. It is evident that farmers tend to be efficient in allocating their resources although there are many site specific factors which affect the yield from farmers' fields.

277. **Consequences research**: It is impossible to give a firm estimate of the impact the new rice varieties have had on production because of lack of data. However, it is estimated that by 1980 modern rice varieties were being grown on 38% of the rice area in South and Southeast Asia. These new varieties gave a yield increase of about 300 kg/ha over those which would have been grown in their absence. This yield increase amounts to nine million tons of increased rice production per year. In most of the areas studied small farmers have adopted equally as well the new varieties as the larger farmers. In 20 farm survey studies in South and Southeast Asia, it was found that farmers growing the new
varieties used 20% more total labour than farmers who did not apply modern technology. In other studies, it was found that farmers applying modern technology used 22% more hired labour than farmers growing traditional varieties.

Monitoring two samples of Philippine rice farmers between 1965 and 1980 showed a dynamic picture of technical change including irrigation intensification, changes in land tenure and spillover effects of non-agricultural modernization. The picture gives a good insight into the economic impact in these rice growing villages. A similar study was done in Indonesia. The research findings in these village studies made it clear that the distribution of benefits and costs of introduction of new technologies must be examined seriously.

Recently IRRI has engaged in rice policy research. This is a collaborative project with the International Food Policy Research Institute (IFPRI), and a network of rice policy researchers in Thailand, the Philippines, Malaysia and Indonesia. A model for technology transfer has been developed and implemented to speed up adaptation of water management and insect pest management technologies.

Evaluation. The above research findings are extremely useful to policy makers, extension workers, and scientists in rice research. This research must be carried out by scientists inside the regions concerned, closely collaborating with agronomists and agricultural engineers. IRRI maintains a good comparative advantage in this research.

In the past five years methodologies were improved and a research network was established in Asia in cooperation with other international centres. It is intended to link constraints and consequences research to the rice policy study. These three research thrusts have to be strengthened. Dissemination of research findings and methodologies could be improved.

Constraints and Future Plans

Shortage of experienced agricultural economists in Asia is a major constraint in the conduct of this research. Such persons work mainly in universities, their interest in these fields is limited, and the dissemination of relevant findings and methodologies is difficult.

As regards constraints research the following future plans are identified:

(i) Farmer's Yields vs. National Average Yields.
The causes underlying the apparent disparities between national average yield estimates and estimates based on actual farm yields will be explored. While part of the differences may be explained in terms of methods of data collection and crop reporting, most of them probably
relate to underestimated agro-economic constraints to crop yields.

(ii) Socio-economic and Institutional Constraints. Factors which may facilitate or restrain the effective use of modern rice technology include: tenure and labour contracts; the farmer's resource endowment; availability of credit and other inputs; and the farm-effective prices of inputs and rice. Studies in five Asian countries (Pakistan, Nepal, Bangladesh, Thailand and the Philippines) are being conducted to examine a range of conditions regarding these factors.

(iii) Crop Management and Productivity. A primary focus of constraints research over the past five years was irrigated rice. In the next five years the focus will shift to rainfed rice. The focus within rainfed environments will be on the shallow drought prone areas, but floodprone stagnant and deep-water areas will also be included in the research.

(iv) Site Related Factors. Present approaches are efficient on a location by location basis, but less adaptable to the analysis and interpretation of results over space and time. Greater attention must be paid to site characterization. Site related factors include water regimes, land factors and the economic environments.

(v) Network Activities. Two innovations in constraints research - those related to constraints in rainfed environments, and the systematic study of socio-economic and institutional constraints - provide an opportunity to enlarge IRAEN network activities. This is done through training, workshops, and by providing, on request, support to national programmes in initiating their own constraints research.

284. As regards consequences research the following are identified for the future:

(i) Monitoring and Analysis of Rapidly Changing Rice Economy in the Philippines. This is a continuation of previous research. Depending on the degree of success, the approach will be applied to other sites.

(ii) Village Economy Accounts. In 1982 a second year of village economy accounts will be completed and will be compared to accounts for the same village five years earlier to learn the impact of changes.
(iii) Joint IRRI/IFPRI/IFDC Rice Policies in Southeast Asia. A prototype computerized model is available and will be refined and applied to the Philippines rice economy in 1982. In subsequent years, it will be extended to other project countries.

(iv) Social-historical Study of the Introduction of New Technologies. This is a study of more developed Asian countries, such as Japan, Taiwan and Korea, and countries in Europe, Japan, Australia and North America, to articulate the lessons that can be learned from their agricultural development experience.

(v) Special project funds will be sought to continue studies of the role that rural sociologists can play in the development and assessment of the consequences of new technology.

Priorities, Future Plans and Recommendations

285. Constraints research and the consequences research interact so closely that it would be useful to retain the flexible division of responsibilities between these areas. Training including some types of conferences, should be expanded. Visits by economists from South and Southeast Asia should be encouraged.

286. The future plans of constraints research follow the lines of the development in the past. Moreover, these plans reflect a re-direction of research activities from irrigated rice to rainfed rice. If these plans are realized they will not only greatly enrich our knowledge of constraints but also the methodology will be developed further. The Panel recommends that these plans be carried out.

287. The first three of the plans for the future ((i) - (iii)) are important and feasible for reasons given above. In the field of consequences research, the Panel does not think that IRRI has a comparative advantage to study the development experience of such countries as Japan, Taiwan and Korea, and of Europe, Australia and North America; this may be left to economists in these countries. Although it has no doubt that additional sociologists or anthropologists could strengthen IRRI's activities, the Panel suggests, that if funds are available, agricultural economists from South or Southeast Asian countries should be invited to IRRI for additional training to strengthen national research capabilities in these fields. The Panel recommends that the monitoring and analysis of the changing rice economy in the Philippines, the village economy accounts and the rice policy project in Southeast Asia be continued.

288. Exploration of the possibility of using constraints and consequences research in the study of projection of future demand and supply of rice is advisable, so as to attempt to quantify the impacts of new technical findings on the future supply of rice.
Research on cropping systems is one of IRRI's major activities, absorbing about 20% of the Institute's budget. The programme was started as multiple cropping systems with the main objective of bringing about better soil-fertility management and improving the nutrition of the small farmer. It later evolved into a rice-based cropping systems programme. The research is farm-based and involves scientists and farmers in a network of activities in several Asian countries in what is now called the Asian Cropping Systems Network (ACSN). The focus is on the development of a cropping systems technology to increase cropping intensity on Asia's rice farms, making more efficient use of the available farm resources. The programme emphasis is resource utilization on small rice farms and includes physical, biological and economic factors at farm level and community factors as they influence the performance of the cropping systems. The cropping systems research concentrates primarily on rainfed rice areas where there is potential for increasing the cropping intensity. In this regard, priority is given to areas where it may be possible to increase production during a crop season and increase the cropping intensity from one to two or from two to three crops. To this end, a number of dryland alternate crops have been included in the research: most common are corn, sorghum, soybean, peanut, mungbean, cowpea and cassava.

Emphasis is placed both on the generation of component technology for cropping patterns and on farmer management of improved technology. The development of methodologies involve: environmental classification, cropping pattern design, technology generation and cropping pattern testing. Through the Asian Cropping Systems Network, IRRI supports cropping systems research in member countries of the ACSN. It provides methodologies, training, information sharing and varietal testing support.

This interdisciplinary applied research programme is organized as a research team comprised of agronomists, economists, crop protection specialists, agricultural engineers, and support research activities at IRRI. The programme has as one of its main components the Asian Cropping Systems Network (ACSN) which at the moment involves nine countries. One scientist serves as the coordinator and another serves as the economist of the ACSN. The ACSN operates on a regional cooperative basis and has formed a working group for this purpose. Each country has a national cropping systems working group and problem area committees. The working groups manage field activities on a regional basis through resident field staff. Cropping pattern trials are conducted on farmers' fields with direct participation of the farmers. The research sites have increased rapidly to more than 100 of which 30 have been selected on the basis of their agro-ecological relevance to the cropping systems programme in member countries. The feedback from site research trials to IRRI is also institutionalized on the same lines and this makes it possible for all participating countries to benefit from each other's experience. The working group encourages greater uniformity in data collection and data analysis at the network sites. This is accomplished through the
establishment of guidelines for these tasks. The working group also participates in project monitoring meetings at which research results and programming for each of the multi-local trial sites are discussed in detail. To raise the capabilities of national scientists in participating in these activities, a non-degree training course is offered annually. The University of the Philippines at Los Baños (UPLB) participates by screening dryland crops for the ACSN. Outside core activities, the programme is financed by bilateral donors and country programmes. Training, regional meetings, conferences and symposia are important elements of the programme.

Main Achievements

292. Progress was made in the analysis of the physical and biological environment. Rainfall distribution maps enabling the design of cropping patterns have been made for nine countries. A detailed land resource survey was carried out in one of the watersheds where IRRI conducts cropping systems research. Experimental procedures that permit the determination of crop losses due to pests at different growth stages have been worked out. Economic analysis takes into account farmers' acceptability of particular cropping patterns at various sites. On-farm site research and farmer participation in the process led to the acceptance of a 'direct seeded rice - transplanted rice crop succession' followed by dryland crops on several sites where only one rice crop was traditionally grown. Crop intensification development projects have been established on this basis in the ACSN (Philippines, Sri Lanka, Indonesia, Bangladesh and Nepal). Agronomic practices have been designed for various intensive production systems.

293. The network has made great progress towards the establishment of national cropping systems research systems programmes with a core of trained staff as integral parts of the national research systems.

Constraints and Future Plans

294. Quick, simple, and reliable methods for characterizing the environment in various climatic zones are needed so as to select and describe research sites and to design improved cropping patterns to permit extrapolation of the results to larger areas. Dynamic simulation models that would enable better understanding of the soil-plant-water relationships should be developed.

295. The market and pricing system should be established with respect to each crop and economic studies should be extended outside the Philippines. A more intensive study of the procedures leading to the adoption of the technology is needed. The principles of cropping systems adaptation to the environment by cross-site studies should be examined. Farm management simulation techniques should be employed in order to determine optimum cropping strategies.

296. Intensification is expected to lead to the development of a wider spectrum of disease and insect problems. A greater awareness is
required by extension agents and farmers in the recognition and control of pests, and IRRI should offer intensive training courses to the widest extent possible in the countries concerned. While safe and economic pesticides must be used in initial stages, the long-term goal should be towards cultural and integrated pest control methods. In view of the current hazards to farmers using pesticides, the use of safe pesticides and pest control equipment should be of paramount importance.

297. Where suitable rice varieties are available for the rainfed lowland and irrigated conditions, short duration rice varieties available for the dryland situations are not well adapted. Furthermore, the performance of dryland 'alternate' crops is not satisfactory. There is urgent need to intensify the selection of dryland 'alternate' crops, and IRRI should focus attention on producing blast resistant, short duration, dryland rice varieties.

298. Germination potential and seedling vigour of direct seeded rice are important factors. Similarly, the soil-plant-water relationship associated with transplanted rice that causes low yields in dryland crops grown before or after the rice would require vigorous selection of varieties adapted to these conditions.

299. Practices that involve mulching and use of green manure and straw, particularly for dryland crops, can enhance yields and improve soil productivity. Cultural practices that save production costs and raise yields, e.g. direct seeding and the use of small tillage, planting, fertilizing and harvest equipment, need further study.

300. Optimum levels of management of the preproduction modules such as the sorjan and rice garden should continue to receive attention. However, every effort should be made to extend preproduction packages outside the Philippines. The potential of Azolla to replace or reduce fertilizer N should be tested within the ACSN.

301. The very rapid expansion in national programmes has led to increased demand for trained personnel. Further, the collection of much basic information is required at the national level. The present dynamic trend in the ACSN can be sustained only by a vigorous training programme. Use should be made of existing national facilities for this purpose. Training is required at both field and professional level.

Discussion of Priorities, Future Plans

302. The IRRI cropping system programme is about seven years old. During this period, it has established a dynamic linkage between the multidisciplinary research team at IRRI and the national programmes. It has established a strong network of national programmes and scientists that contribute to the planning of the research activities at national and regional levels through the Asian Cropping Systems Network. The programme has developed research methodologies and has fostered excellent relationship with these countries. Finally, the system permits the small scale
farmer to be involved in the planning and execution of field trials on his farm to ensure that the methodology is acceptable to him. This programme has been so successful that many governments are putting heavy demand on IRRI to develop cropping systems programmes in their countries. The programme has had without doubt, a great effect and impact on the Indonesian and Philippines cropping system activities. Apart from the incapacity of IRRI to accommodate all requests from governments, there are other problems which have to be resolved as the programme grows older.

303. There has been great progress in the analysis of the physical and biological environments. The integrated approach adopted in this programme is commendable. These inventories would provide an important complement and give a broader perspective to the work being carried out by the soil chemistry and agronomy departments on individual land characterization factors, and thus enable IRRI to select and better assess the different target areas and sites for its programme. This is needed at a time when the institute plans to place a growing emphasis on more difficult environments. While this work continues to be refined, it is now necessary to characterize the results obtained to enable rapid systematic design of specific cropping patterns to suit various environments and to be able to extrapolate such patterns into similar ecological situations. This work needs particularly the support of national research systems. It should be noted, however, that while it is essential to cover the important agro-climatic zones with multi-location testing (the numbers of trial sites would tend to reduce testing time), quality of trials is more important than the number of trial sites. On the other hand, long-term trials are essential in such areas as residual fertilizer effects, and tillage effects on soil structure and crop production.

304. A major part of the success of the programme can be attributed to the short duration rice varieties that have been developed at IRRI for irrigated and lowland rice cultures. However, it is recognized, and there are indications, that intensive and wide scale cultivation of varieties may lead to the breakdown of resistance under pest pressure. Unfortunately, for dryland cultivation, there is no improved variety with the required growth duration that is blast resistant. This implies that stable systems cannot yet be evolved for rice-based upland cropping systems. Another serious drawback in the area of component technology is that most of the dryland alternate crops are low yielding and with few exceptions have little pest and disease resistance. Much work still needs to be done in this area. Prescreening of plant materials in the Philippines, which are already fixed before they are introduced into the Philippines for further distribution to other countries, may lead to the loss of valuable materials for certain ecologies. Preliminary screening can best be done in the countries concerned.

305. Much progress has been made with cultural practices for rice-based cropping systems. Direct seeding, minimum tillage practices, small scale mechanization for land preparation, planting, fertilizer and insecticide placement, harvesting and threshing, where applicable, have reduced labour costs, decreased turn-around time and increased
farmers' yields. There has been greater integration of the cropping systems programme and farm mechanization. Increased participation of local manufacturers in adapting the IRRI machinery designs to local needs is outstanding. So also has been the collaboration between IRRI and other international centres, in particular IITA from which improved cowpea varieties and the rolling injection planter have been introduced.

306. The tillage effect on soil structure after alternate wetting and drying in crop intensification was raised in the first Quinquennial Review. Tillage and alternate wetting and drying have serious implications on the productivity of dryland crops that are utilized in the cropping system. It is essential to conduct studies on the effects of tillage and crop intensification on soil structure and crop productivity. Plant-soil moisture studies should also form a valuable part of the environmental characterization work in this programme.

307. The tendency in almost all the countries with a cropping systems programme is to follow up with farming systems. Some countries have expressed a desire for IRRI to assist them in this endeavour. The introduction of animals or tree crops or fish into the system is outside IRRI's mandate. However, IRRI has played a strong role in developing the methodology used in the ACSN. It is logical that it seeks the cooperation of other competent national and international institutions in and outside Asia in working towards a comprehensive and integrated approach. In practice, both rice-based cropping systems and farming systems research can best be managed by national programmes once the methodology has been delivered. IRRI might consider enlisting the involvement of other IARCs in supporting such programmes. In Indonesia, it is planned to involve IITA for such aspects as land clearing and development, soil management and the supply of planting materials. The Asian Vegetable Research Development Centre (AVRDC) might assist in the supply of vegetable crop varieties for the ACSN.

308. A great advantage of the ACSN is the fact that most of the funds for local activities are provided by the countries concerned and through bilateral aid. There is therefore no immediate need for IRRI to expand its core facilities to support these activities except in such areas as training. Thus with time, the countries should strengthen their capacities to take over the scientific responsibility for their programmes. The weakest link in every country is the lack of trained manpower. The highest priority should be given to training at all levels for the ACSN.

Conclusions and Recommendations

309. The Panel commends IRRI for its dynamic and well integrated cropping systems programme and suggests that the programme be kept at its current level of core input. Special project funding should be encouraged for country programmes.
310. The Panel supports the integrated approach followed in the analysis of physical and biological environment and suggests that similar methods be used on a smaller scale to develop synoptic inventories of the main rice lands of Asia by enlisting the cooperation of the national programmes concerned and the help of postdoctoral fellows and consultants from institutions familiar with these methodologies.

311. The supply of high yielding pest and disease resistant upland crop varieties is the weakest link in the chain of component technology in the cropping systems programme. IRRI should foster stronger ties with other IARCs and national programmes working in this area and try to make maximum use of available materials. In view, also, of the dangers inherent in the intensive and widescale cultivation of certain rice varieties such as IR36, steps should be taken to diversify the use of varieties in the cropping systems.

312. Intensive cropping practices may give rise to an array of insect pests and diseases. The use of pest control chemicals therefore appears at the moment, to be essential for the cropping systems programme. However, their use has proven uneconomic partly because of high costs, and dangers to the users as the result of farmers inability to apply the right doses and/or make the right use of the equipment for application. In developing countries serious problems with regard to pesticide safety may occur. Where intensive rice cultivation implies the use of pesticides which may even endanger the very lives of the users, IRRI has a responsibility in promoting the safe usage of pesticides, for example by stressing the point specifically in its training programmes.

313. The Panel recognizes that the successful transfer of cropping systems methodology to countries requires a strong local core of trained technicians and professionals. The Panel notes that the supply of trained manpower should be enhanced. Courses should be organized at IRRI and on national or regional basis wherever the opportunity exists.

314. The Panel notes that in all countries where IRRI has introduced the rice-based cropping systems activities, the ultimate ambition of governments is to develop farming systems, and considerable pressure is being brought to bear on IRRI by certain governments to move in this direction. The Panel further notes the limitation imposed by the IRRI mandate but recognizes IRRI's important link with national programmes in the area and its proven ability to deal with these problems. The Panel also notes the geographical location of IRRI relative to the other IARCs which have mandates for dealing with this problem and recommends that IRRI facilitate the cooperation of competent national and international institutions in bringing expertise to those elements of the farming systems programme that are not covered by IRRI.
Machinery Development and Testing

Background and Objectives

315. Machinery development and testing started at IRRI under special fund support from the Agency for International Development (USAID). In 1975 the first Quinquennial Review Panel recommended that the programme be made part of the core programme of the Institute. This has been done. The programme is now a blend of core and special project activities. Primary support for special projects is provided by USAID.

316. The objective of the programme is development of machines for small rice farms in the two to five ha size range by: (i) assisting national organizations to introduce improved, economically feasible machines to improve farm productivity; (ii) developing the capacity of small manufacturers in rural areas to produce simple farm machinery, and to develop rural employment opportunities; and (iii) reviewing the impact of a new machine on farmers' income, productivity and labour needs. To meet these objectives the following procedures have been adopted: (i) identify aspects of rice-based farming systems where there is a need for simple machinery or tools; (ii) design, test and evaluate prototypes of machinery and tools that may be relevant to rice farmers; (iii) develop prototypes such that small scale local manufacturers may undertake commercial production of the machines; and (iv) provide technical assistance and training to encourage establishment of an indigenous manufacturing programme in selected countries. The latter two procedures are carried out under a special project.

317. The programme not only designs equipment, but also modifies existing equipment developed at IRRI or elsewhere to fit the needs of small farmers and manufacturers. It works closely with several other IRRI departments, notably agronomy, cropping systems, and economics.

318. The main principles underlying the mechanization programme are: (i) to increase the productivity of land by improving timeliness and efficiency of specific agricultural operations and by increasing cropping intensity; (ii) to increase the productivity of man by decreasing drudgery and time required for tasks during critical periods; and (iii) to decrease post harvest losses by more timely and efficient harvesting, threshing and drying of rice. IRRI maintains the patents for the machines, but plans and rights to produce the machines are provided free to manufacturers in developing countries.

319. Besides carrying on design, evaluation, and training activities, core staff provide backup support for the Industrial Extension Programme (supported by special project funds) which operates in Burma, Egypt, Indonesia, the Philippines, Pakistan and Thailand. Staff of the Industrial Extension Project assist national organizations to provide plans, advice and training for small scale local shops and manufacturers to build and distribute equipment designed or modified by IRRI.
Achievements

320. The machinery programme has developed an impressive array of simple, sturdy, and versatile machines for use in growing and harvesting rice. Of these, the portable axial-flow thresher is undoubtedly the most successful. Available in several models, both in regard to size and capability, the thresher is being built in large numbers in several countries, particularly in the Philippines, Thailand, and Pakistan. Farmers purchasing the threshers report that often their earnings from the thresher are sufficient to pay for its cost in a year or two. Rural industry has been created, resulting in new employment opportunities, and harvesting has been made easier. The thresher has become especially popular in the central Philippines where double cropping has been introduced as a result of the IRRI Cropping Systems research programme; here farmers use the thresher for the increased rice production which has resulted from growing two crops of rice plus an upland crop where only a single rice crop was grown before. The thresher has been modified to thresh other crops in places where farmers grow cereal crops other than rice, e.g. wheat in Pakistan and sorghum in the Philippines.

321. Another very successful machine has been the IRRI power tiller which has been adopted widely in the Philippines, where more than 10,000 tillers have been built since the machine was released by IRRI in 1972.

322. Other successful machines now going into the Industrial Extension Programme include: the five-row seedling transplanter, the axial-flow low lift water pump, and the hand-operated rotary weeder. Other prototype machines are sent to the cooperating countries, and tested and modified as needed. IRRI provides necessary plans and training for local craftsmen to help them manufacture and sell relevant equipment. Some equipment is received better in one country than in another, e.g. some 600 transplanters have been built in Burma.

323. The programme has made significant progress in improving the seeding of upland crops for multiple cropping, in redesign and testing of a Chinese designed mechanical rice reaper (in cooperation with Chinese engineers), and in the development of several prototypes for deep placement of nitrogen fertilizers in flooded rice fields. The latter work is being carried out in collaboration with the soil fertility and cropping systems programme.

324. Studies of the economics of mechanization have yielded some important results. For example, although mechanization of some aspects of production of modern rice varieties does increase the energy requirement on the farm, the largest quantity of energy is supplied as chemical fertilizers and pesticides. Also, as regards effects on employment, as farmers mechanize they frequently increase the use of hired labour, freeing children to go to school and the wife for home improvement. In the Philippines, mechanized farms employed more labour than farms using water buffalo as a source of power. At a village in the Philippines where the new double cropping of rice had been adopted, farmers told members of the Panel that the males no longer left the village to seek employment outside since the labour demands of the new technology provided sufficient employment and income for farmers. In this village much of the land
preparation is done with power tillers and all of the threshing is done with the axial-flow thresher. Here, increased cropping intensity and production required both more labour and mechanization to meet the needs.

325. The Industrial Extension Programme promoted the establishment of the Agricultural Machinery Network (AMN). The AMN has established close working relationships with national engineers and small manufacturers in rural areas of several Asian and Latin American countries, to build up an indigenous manufacturing capacity. It assists these manufacturers in producing appropriate machinery for the small farmer and to train young engineers at IRRI.

Constraints and Future Plans

326. A major problem limiting rice production is the poor efficiency and utilization of nitrogen fertilizers, mostly due to nitrogen losses. Such losses could be alleviated by deep placement (10 cm) of nitrogen fertilizers in the paddy mud. Several types of machines have been designed to meet needs specified by IRRI agronomists and cropping systems specialists. A variety of machines, including hand-operated types, will be developed to meet the needs of a range of farm sizes.

327. The 3 HP tiller will be developed and tested for use on small farms too remote for access by larger equipment. A line of equipment will also be developed that, along with the tractor, can be carried by two men.

328. Equipment for upland crops grown in association with rice is needed, especially for intensified cropping systems. Of particular interest is the improvement of the hand-operated, IITA-designed, rolling injection planter for areas where stubble or mulch cover the soil surface and where zero or minimum tillage systems are used. Cultivation and tillage equipment is also needed for upland areas to assist low input, intensive crop production efforts.

329. Land preparation equipment suited for minimum or zero tillage systems is needed.

330. The Industrial Extension Programme under special project support will emphasize the following work:

(1) Philippines - More assistance, including training, will be provided to government and private agencies to increase local manufacturing of IRRI-designed equipment.

(2) Thailand - Training for government engineers and manufacturers will be conducted in the Thai language, and standards for IRRI equipment will be translated into Thai. An improved local plough from northern Thailand will be tested and introduced into other areas.
(3) Indonesia - Manufacturers and engineers will be familiarized and trained on IRRI machines in the local language. IRRI machines will be introduced and tested on the outer islands, to compare their use with traditional production methods, in particular animal traction.

(4) India - A unit will be located at Tamil Nadu University in Coimbatore, Madras. IRRI designs will be introduced and manufacturers will be assisted.

(5) Assistance will also be given to industrial extension staff in Bangladesh, Burma, Egypt, and Pakistan.

(6) Training of country personnel is now conducted at IRRI. As the Industrial Extension units develop, training of key personnel from the countries will be conducted at IRRI, and these persons will then conduct training locally in the local language.

Conclusions and Recommendations

331. The machinery programme has been very successful. It has designed equipment that has been adopted by farmers and that has been manufactured by local shops. The programme has had a marked effect in developing indigenous industrial capacity and in improving farm production.

332. The work on the thresher has been especially important in saving labour and improving harvest timeliness and effectiveness.

333. The work on deep placement of nitrogen fertilizer is important and should be pursued vigorously. The modified reaper is simple and effective and can be easily manufactured by local shops; it should prove very useful in places where labour is short or where a short turnaround time between crops is essential.

334. For the future, several developments in rice production will require mechanization assistance. IRRI has anticipated most of these, with increased emphasis on improved establishment of upland crops, the need for small tillers and equipment for small remote farms growing modern varieties, and the farm labour shortages in some situations at planting and harvesting time.

335. Some areas that may require more attention in the future are effective, low cost grain dryers, and improved small farm equipment for applying fungicides, insecticides and herbicides. The Panel recommends that grain dryers be given high priority by the core staff, since double cropping often results in high-moisture rice during the height of the rainy season. Effective, less expensive dryers are needed that can be fueled by local materials. The work on the rice-husks furnace is commended as a start in this direction.
336. The programme should remain at its present level, and as new problems or needs arise, special project funding should be considered as a means of support.
Chapter IV. IRRI AND UPLAND RICE RESEARCH

337. In response to a pertinent question put forward by TAC, a special chapter is devoted to upland rice. This chapter emphasizes the importance of upland rice in relation to the numbers of people involved and in terms of equity. Also, the chapter brings forward the discussion of the problem in terms of difficulties anticipated and of scientific effort needed.

338. At the request of TAC, the Panel specifically examined the activities of IRRI in relation to upland rice. In February 1980, TAC convened a special meeting on this subject with representatives of the IARCs concerned. With the help of several consultants, TAC formulated a series of recommendations 1/ aiming at a better focus and coordination of the IARCs' activities in this field. The Panel was requested to review the progress and future of these activities at IRRI. A revised version of the document 2/ which had been submitted earlier to TAC by IRRI was presented to the Panel. A special session on upland rice was organized during the Review. It was attended by the whole Panel and some 25 members of the IRRI Directorate and senior staff of all the departments concerned.

339. It was noted that upland rice is far from being a new concern at IRRI and the Panel had ample evidence of the interest of IRRI in many relevant aspects of upland rice research (genetic resources, breeding, disease and insect control, soil and crop management, physiology, environment, cropping systems and economics). The many publications of IRRI on upland rice research and related subjects in all these fields, and several compilations of existing literature and proceedings of scientific meetings, amply illustrate the interest of IRRI in this field.

340. Some of the achievements reported by IRRI include:

a) the characterization of the special factors and mechanisms which govern the rice plant under upland conditions, in particular as regards drought tolerance,

b) the development of mass screening methods and the assessment of breeding lines for upland conditions,

c) the identification and study of the main diseases and pest problems of upland rice,

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1/ Reference to 23rd Report of TAC, AGD/TAC:IAR/80/18

2/ "Base paper from IRRI relating to Upland Rice on Asia and related research and achievements by the International Rice Research Institute" Revised for IRRI Quinquennial Review, December 1981.
d) the establishment of cultural methods for crop management, fertilization and weed control under upland conditions,

e) the study of some cropping systems related to upland rice, and

f) the study of the constraints and prospects for upland rice improvement both from the physiological and environmental points of view and from the economic point of view.

341. Because of the diversity and complexity of the conditions under which upland rice is grown - climate in particular is a major obstacle - and of the range of adverse factors affecting its production, IRRI’s research efforts may appear somewhat fragmentary. The impact of IRRI’s research is necessarily more limited and less spectacular than in the more favourable conditions of irrigated rice. Nevertheless, it was reported that two varieties developed by IRRI especially for upland rice conditions have been released in the Philippines, yielding almost twice as much as the local varieties. Moreover, several of the IRRI lines developed for irrigated conditions proved also to have superior performance under favourable upland conditions. Several other lines are being tested on an international scale through IRRI’s Upland Rice Nursery but with limited success, particularly in Africa and Latin America.

342. The results of these efforts may seem at first sight disappointing when considering the relatively limited impact of IRRI’s upland rice research. The Panel had extensive discussions on the causes of this limited impact, and found that there are both basic reasons and particular circumstances which explain this situation.

343. The wide range of conditions under which upland rice is grown, the variability of climatic conditions in particular, make it difficult for an international research programme to determine a common denominator among national and local problems to define its target areas, especially in terms of breeding objectives and agronomy. Progress has been made in developing a common classification of upland rice conditions, but there is still no complete agreement among the specialists concerned on the adverse categories, their characteristics and limits. It is therefore, not surprising that although some statistics were assembled on upland rice, there is no precise knowledge of the extent, location, characteristics of the main areas where upland rice is grown. Although progress was made in the understanding of drought tolerance and of the general conditions of growth under upland conditions, further basic studies are necessary to define the most suitable plant types for the main categories of upland rice. Consequently, the breeding approach followed so far has been derived from that used for irrigated rice rather than having a strategy, a focus and methodology of its own. Similarly factors affecting upland rice were studied not specifically for these conditions but rather as factors affecting several categories of rice cultures.
Progress in upland rice is also hampered by its particular susceptibility to blast and, therefore, by difficulties which IRRI and other research institutions are facing in the control of this disease.

Finally, the marginal areas, where upland rice is grown, have not received the same attention from the national programmes as the irrigated areas where socio-economic conditions are more favourable for the adoption of modern technologies. In upland areas these conditions tend to limit the use of agro-chemicals and other technologies which are essential to improve their generally low fertility and to control the pests and the weeds which are particularly aggressive under upland conditions.

Beside these constraints which are to a large extent inherent to upland rice research, other constraints affected IRRI's progress in this area. IRRI has not been successful so far in its attempts to select and obtain an adequate research site for upland rice in the Philippines. Moreover, although a number of IRRI scientists were and are still working on some aspects of upland rice, the Panel was not able to identify a clearly defined, integrated and focussed programme in this field. Beside the reasons which have been presented above, budgetary constraints may also have hindered the implementation of TAC's recommendations, i.e. a more clearly identifiable upland rice basic research programme at IRRI and a more active role in the international coordination and promotion of upland rice research. Nevertheless, IRRI's estimates of its current expenditures on upland rice improvement are difficult to analyze because of the present structure of the multidisciplinary programmes and of the different departments involved, as well as the different definitions used in categorizing rice cultures. IRRI reports that about one quarter of its resources and 13% of its senior scientist's time are allocated to upland/rainfed dryland rice. IRRI's future plans call for a general increase in rainfed rice research which include both wetland and dryland rice and a continuation of its research to increase the yield potential of dryland rice. To this end, IRRI requests the establishment of a new post of dryland rice coordinator.

The Panel generally concurs with IRRI's intent to place more emphasis on rainfed rice research and to continue its basic research activities on upland rice. Although upland rice covers roughly 10% of the areas where rice is grown in the world, these areas are among those in which technological and socio-economic progress has been slow and will continue to be slow, unless a special effort is made for reasons of equity, particularly for the small farmers which predominate in these areas. The Panel shares IRRI's concern that in spite of its

Using a broad definition of upland rice IRRI estimates that about 19.5 and 2 million hectares are covered by upland rice in Asia, Latin America and Africa respectively.
and other research efforts, "no new variety or new technology is available for wide scale adoption" in these areas as far as rice is concerned. The Panel believes that the formulation of a clearly identifiable and integrated programme focussed on upland rice at IRRI should receive a high priority. The appointment of a full time leader for this programme is essential for its proper implementation. The Panel is not convinced that a programme coordinator with limited responsibilities will be able to put this programme into operation.

348. The development of a well focussed programme on upland rice should not only involve several elements of IRRI's research departments but also make use of resources and expertise available in other international and national institutions. The function of coordination will then be facilitated by the very existence of this programme: as this programme will make progress and establish a stronger basis of fundamental knowledge and scientific expertise in this particular field, IRRI can be expected to play a wider role of leadership and coordination among other national and international institutions which also carry out research on upland rice (CIAT, WARDA, IITA, TRAT, CNPAPF, etc.).

349. The need for an additional position (of upland rice research leader rather than coordinator) will also depend on the structural changes which may affect the future organization of IRRI and its cooperation with national programmes (in particular within GEU as a whole, as discussed in the relevant chapter of the report). In this report, linkages both inside IRRI and outside would be essential to the success of the programme.

350. The Panel gives particular importance to further progress at IRRI in this field and recommends that if such position cannot be found by appropriate shifts within the existing staffing authorization, additional funds be sought to establish the required position. It is obvious that, when establishing this special position of senior scientist on upland rice, supporting staff, services and facilities will also be required including those of collaborative networks such as IRTP.

351. Meanwhile, the Panel welcomes the growing number of international scientific meetings which have been held with the participation of IRRI staff recently on subjects related to upland rice such as drought tolerance and blast. It notes with satisfaction that other meetings are being planned which may focus more specifically on upland rice research and its coordination. The Panel encourages IRRI to play an active role in these meetings and to expand its cooperation with the other institutions involved in upland rice research not only in Asia but also in Africa and Latin America. The Panel recommends that the international meeting to be held at Bouake (Ivory Coast) on upland rice research devote particular attention to the development of the programme mentioned in the preceding paragraphs. The Panel also suggests that this meeting be attended by potential donors and administrators who may assist in the speedy implementation of this important undertaking.
352. Dissemination of rice technology and strengthening the national rice programmes are major responsibilities of IRRI. Those activities cut across all problem areas discussed in the foregoing chapter. Below, activities are discussed under two major headings: International Cooperation, and Training and Conferences.

(a) International Cooperation
Background and Objectives

353. IRRI's role is to help increase the rice production of the developing nations by generation and dissemination of technology and by strengthening national rice research programmes. To achieve this IRRI has extensive cooperation with national research institutions, as well as with other International Agricultural Research Centres.

354. The stated objectives of this cooperation are:

(1) to provide assistance to the national rice programmes

(2) to encourage strong national programmes to carry out joint projects or research on problems of mutual interest, and

(3) to complement location-specific research which cannot be done at IRRI headquarters.

355. Due to the high variability of the rice ecology (soil types, water regime, climate, pests and diseases) as well as marked differences in the socio-political and economical environments where rice is grown, different patterns and types of collaborative activities have evolved.

International Research Network

356. The networks provide an opportunity: to test materials from IRRI's germplasm collection, improved material from IRRI and from national programmes, under different conditions; for national and IRRI scientists to consult each other and jointly develop research programmes; for exchange of information, and for feedback to IRRI concerning national rice production problems which require special attention. Monitoring tours to evaluate the programme in the field, and workshops are held for further assessment of its progress for improvement. These monitoring tours are effective in transferring knowledge and promoting the involvement and collaboration between scientists among developing countries.

357. Table 4 shows IRRI's international networks, regions in which they operate, numbers of sites and numbers of cooperating scientists in the respective networks.
358. The International Rice Testing Programme (IRTP) initiated in 1975 is an effective international network activity for rice improvement among national rice programmes and between IRRI and the national programmes.

359. The nurseries provide evaluation of resistance to important rice pests and of tolerance to environmental factors such as drought, adverse soil conditions and temperatures. The tested varieties include materials from both national programmes and IRRI (ref. para. 96).

360. The Asian Cropping Systems Network (ACSN) serves to develop cropping systems technology for different rice environments in the region. The cropping systems research at the network sites concentrates on design and testing of cropping patterns and on component technology research, such as varietal testing, fertilizer studies and pest control.

361. The International Network on Soil Fertility and Fertilizer Evaluation on Rice (INSFFER) initiated in cooperation with scientists in national programmes and with the International Fertilizer Development Centre (IFDC), aims at evaluating under different ecological conditions the effects on rice production of improved fertilizer formulations and placement, and of biologically fixed nitrogen. Initially, the research focussed primarily on the efficiency of phosphorus fertilizer and the use of the Azolla-Anabaena complex for biological nitrogen fixation.

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Table 4: IRRI's International Networks 1/

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<tr>
<th>Networks</th>
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<th>Region</th>
<th>Number of Sites/Organizations</th>
<th>Number of cooperating scientists</th>
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<tr>
<td>INSFFER</td>
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<td>Asia</td>
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<td>50</td>
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<td>AMN</td>
<td>9</td>
<td>Asia, Latin America</td>
<td>12</td>
<td>20</td>
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362. The International Rice Agro-Economics Network (IRAEN) strengthens the capability of national rice research programmes to undertake constraints research on rice production, such as biological, physical, institutional and socio-economic environments. It develops methods and techniques to quantify rice production constraints at the farm level.

363. The Agricultural Machinery Network (AMN) promoted by the Industrial Extension Programme (Machinery Development and Testing), works with national engineers and small manufacturers in rural areas of several Asian and Latin American countries to build up an indigenous manufacturing capacity. It assists these manufacturers to produce appropriate machinery for the small farmer and to train young engineers at IRRI in machinery manufacturing.

**National Programmes**

364. IRRI cooperates with several developing countries with the objective to support the development of local institutes (Bangladesh, Indonesia), to strengthen rice-based cropping system research capability (Bangladesh, Burma, Indonesia, Sri Lanka, Philippines), to develop and implement inter-disciplinary programmes in rice varietal improvement (Indonesia, Burma, Sri Lanka), to promote machinery development and testing (Egypt, Indonesia, Pakistan, Thailand, Burma), to develop applied research trials (Egypt, Pakistan), to assist in the transfer of technology (Philippines) (see Annex V.).

**Regional Liaison**

365. Liaison scientists are located at Bogor, Indonesia, for liaison with Indonesia, Malaysia and Sabah, at IITA for Africa, at CIAT for Latin America, and in New Delhi for India.

366. These scientists supervise the operations of the collaborative research projects, particularly IRRI's network of testing (IRTP) and the Cropping Systems Network. The liaison scientists can establish cordial contacts between IRRI and the government officials, and facilitate the cooperation with IARCs and national rice research programmes.

**Core Research Programmes Outside the Host Country**

367. The Deep-Water Rice Project, which is core funded, is located in the Huntra station in Thailand because there are no convenient deep-water sites in IRRI's host country (ref. para. 92).

**Collaborative Research Projects**

368. IRRI carries out a series of collaborative research projects with institutions in developing and developed countries on subjects of mutual interest.
(i) With Developing Countries:

369. IRRI develops research projects on cropping systems in rainfed or partially irrigated rice areas (Indonesia), exchange and evaluation of germplasm for specific pests and diseases (India), screening for cold tolerance and blast resistance (Korea, Philippines), consequences of mechanization (Indonesia, Philippines, Thailand), nutritional and acceptability problems related to rice-based diets (Philippines), organization of small farmers for effective use of technology (Philippines), gene rotation (Philippines, Korea), hybrid rice (China), tissue culture (China), adaptation of small machineries to local conditions (China), support for resettlement of farms (Philippines). These collaborative projects have also provided opportunities for exchange of scientists and information mainly with Cuba, Vietnam, India and China (Annex V.).

(ii) With Developed Countries:

370. This involves research of a more fundamental nature and usually concerns specialized assistance to resolve particular research problems such as studies on sex pheromones with the Tropical Products Institute, U.K.; ecology of brown planthopper with the Centre for Overseas Pest Research, U.K.; microbial control in insects and N-fixation with the Boyce Thompson Institute, U.S.A.; studies on organic matter with the University of Hamburg, West Germany; spore formation of Azolla with the University of Manchester, U.K.; studies of bacterial leaf blight with the Kyushu University, Japan; and some others.

Germplasm Collection, Preservation and Utilization

371. This activity is being implemented in Bangladesh, Burma, China, India, Indonesia, Nepal, Sri Lanka and Thailand. These materials are made available to rice breeders throughout the world.

Consultancies to National Programmes

372. IRRI has no formal scheduled programme of consultancies to national programmes, however, this activity is undertaken extensively, i.e. visits of IRRI scientists and administrators to the national programmes; invitation of national rice scientists to conferences and workshops at IRRI.

Relationships with other IARCs

373. Collaboration between IARCs (WARDA, IITA, CIAT, IFPRI and IBPGR) is actively pursued in order to enhance the strengthening of national research capabilities, to avoid unnecessary duplication and to facilitate integration of the research efforts of the IARCs. In this context IRRI has collaborative agreements with CIAT, WARDA and IITA, laid down in memoranda of understanding with each of them.

374. According to these memoranda the Centres agree to develop and conduct joint rice research and training programmes with IRRI to meet
the needs of the relevant regions. From time to time, the Centres involved will review with IRRI the research needs of their regions, establish priorities and ensure that their inputs are complementary to each other.

375. In addition to the joint programmes with the collaborating Centres, IRRI has a comprehensive research and training programme at its headquarters which can provide research information to these regions and training to selected individuals from there.

Main Achievements

376. The achievements reported below are the results of the various kinds of cooperation of national programmes with IRRI.

377. Cooperative Country Projects

Bangladesh - The BRRI has become the premier rice research institute in Bangladesh with a well trained staff, research development and improved laboratories and research stations. IRRI reports that self-sufficiency in rice would be nearly accomplished in 1980-81.

Burma - Significant progress has been made in improving the varietal improvement programmes, evaluation of IRRI-designed machines, and establishment of cropping systems research sites.

Egypt - Development of programme in mechanization and applied research trials.

Indonesia - Successfully strengthened the rice research programme of the country (GEU, cropping systems, agro-economic constraints on rice yields and mechanization). A dramatic rice production increase has taken place during the last few years. Strengthened the Sukamandi rice research station.

Pakistan - Successful establishment of IRRI's small-scale farm machinery industrial extension project. Packages of rice production technology being advanced into pilot extension projects.

Philippines - Self-sufficiency in rice has been largely accomplished through Masagana 99 to which IRRI contributed in training of personnel, and carefully tested packages of technology for farm adoption.

Sri Lanka - Successfully strengthened the organization of multi-disciplinary research on varietal improvement and cropping systems.

Thailand - Increased the effectiveness of small-scale machines project for the Thai manufacturers and in modifying and evaluating several IRRI-designed machines.
Regional Liaison

378. IRRI reports that its liaison scientists have been useful in strengthening the ties between IRRI and national programmes and with sister-institutions. However, their functioning is difficult in situations where communications are poor, and/or staffing and other facilities are limited. This is particularly true for Africa.

International Research Networks

379. IRTP - Entries from 1979-80 identified highest yield performance across many sites, high phenotypic acceptability scores in various target environments, and good resistance to various stresses.

INSFFER - Achievements are noted in more efficient application of N fertilizers of different sources and methods in both irrigated and rainfed rice. Azolla experiments produced very significant yield responses.

MACHINERY - Development of several types of agricultural machines for soil preparation, transplanting, harvesting and drying. Several of these are being modified and used by the farmers in various developing countries.

IRAEN - Development of methodology for an integrated experiment-survey on rice yield constraints.

CROPPING SYSTEMS - More intensive cropping patterns with relatively low input levels have been designed and introduced into areas where production increases appear to be possible.

Collaborative Research with Developing Countries

380. Indonesia - Marked progress in developing technology for rainfed and particularly irrigated rice.

India - Exchange of germplasm for work on resistance breeding to insects and diseases has been mutually beneficial.

Philippines - Work on pest control method, cropping systems, and nutritional evaluation made significant progress.

Korea - Collaborative projects on screening cold tolerance and blast and work on gene rotation has been very successful.

Indonesia/Philippines/Thailand - The consequences of mechanization study is indicating that mechanization is needed and can lead to increased production without adversely affecting labour opportunities.

Cuba/Vietnam - Provided opportunities for close cooperation between IRRI scientists and those of these countries.
China - Workshops on hybrid rice and tissue culture, GEU, IRTP, INSFFER network monitoring tours, adaptation of Chinese reaper, assistance in planning the National Chinese Rice Research Institute reflect close cooperation.

**IRRI Relationship with IARCs**

381. The location of the IRRI liaison scientists in IITA and CIAT is reported to facilitate activities, such as IRTP, exchange of plant materials, germplasm collection, monitoring tours, participation of national scientists in working groups, workshops and conferences. The IRTP has been the main link between IRRI and the national programmes in Africa and Latin America.

382. Several original IRRI lines of irrigated rice have been grown commercially in various West African and Latin American countries. West African materials contributed significantly to resistance breeding for drought and green leafhopper.

383. IRRI provided short-term research and rice production training to young scientists of WARDA and of several West African countries.

**Constraints and Future Plans**

384. Funding for cooperative projects is strictly on a short-term basis. It means that no long-term commitment can be made to scientists assigned to cooperative projects. This creates problems as recruitment of outstanding scientists on a short-term contract is very difficult. The cooperation between IRRI and national programmes in developing countries outside Asia is carried out mainly through other international centres located in the regions (IITA and WARDA for Africa and CIAT for Latin America). Agreements for cooperation signed between IRRI and the IARCs (CIAT, IITA and WARDA) have not been fully implemented so far and the relationships are becoming more and more informal. Under the above agreements IRRI scientists should meet with scientists from the other Institutes for evaluation and planning of the future work. However, this is not done. The agreements do not indicate which Institute would be responsible for the initiatives and this seems to be one of the constraints for its implementation. Also, the TAC recommendation that IRRI should assume the global leadership on upland rice research has not received adequate attention. The full implementation of the above memoranda of understanding should enable IRRI to coordinate rice research on a global basis. It should also facilitate the contribution of IRRI to areas outside Asia with regard to material from its germplasm bank, segregating materials from crosses specially requested by the collaborators, training of national researchers on special subjects, and development of basic research on special subjects.

385. The five International Research Networks will be continued at approximately the present day level, subject to modification when needed.
Other research networks might be developed if considered necessary by developing countries.

Conclusions and Recommendations

386. The Panel noted that in general the various kinds of international cooperation of IRRI with developing countries in Asia have increased in scope, intensity and quality. Consequently, the national rice programmes of these countries are gradually being strengthened. As the national programmes are becoming stronger the future collaboration evolves accordingly.

387. The Panel supports IRRI's off-campus activity and strategy for Asia. To strengthen this, the Panel recommends:

a) To continue and improve relationships with developing countries through more intensive consultation.

b) To extend the recently developed annual programmes with the developing countries.

c) To increase cooperative work with developing countries which have specific rice cultural environments.

d) To promote the cooperation among developing countries in fields of common interest.

e) To strengthen the collaboration between IRRI and other IARCs.

388. For cooperation with national programmes from developing countries outside Asia the Panel reiterates the recommendation made elsewhere in the report that IRRI updates the interpretation of its mandate in relation to its responsibilities to these areas. The Panel also strongly recommends that the agreements with other IARCs (CIAT, WARDA and IITA) be more effectively implemented.

(b) Training and Conferences

Background and Objectives

389. In the next decade as in the past years, IRRI will continue to sponsor training of scientists from developing countries so as to strengthen national research capabilities and rice research programmes. The training programmes consist of:

390. Degree programmes in cooperation primarily with the University of the Philippines at Los Baños (UPLB) and with Cornell University. These are research-oriented programmes leading towards M.Sc. or Ph.D. in various disciplines of rice research. The course requirements are completed at the UPLB and the research for the thesis is accomplished at IRRI supervised by the research staff. The research programme is designed to expose
the students to the new methodologies of direct relevance to the problems they will encounter in their respective countries. The supervisory research staff of IRRI are affiliated committee members of the graduate school at UPLB. The degree is awarded by the UPLB.

391. In the case of the arrangements with Cornell University, the course work is done at Cornell while the research portion is done at IRRI. The final examination will be carried out at IRRI by both the IRRI supervisors and the extended Cornell graduate committee.

392. Non-degree training programmes are of four to six months or one to two weeks duration as described below:

393. The Rice Production Training Programme (RPTP) - five months - is now being reoriented to become a Rice Production and Rice Training Programme. More emphasis will be given to research methods and less to extension and production. The reason is that IRRI's primary competence is in research, whereas production conditions are highly site-specific and variable. The participants will be selected from research staff of research institutions in developing countries. There is also a simplified two-week RPTP, which is held six times a year.

394. The Cropping Systems Training Programme (CSTP) - five months - is offered annually to train the participants in methodologies, in designing and conducting appropriate research, identifying production constraints and developing production technology for rice-based cropping patterns and applying the recommended production and management skills in more intensive cropping systems.

395. Genetic Evaluation and Utilization (CEU) - four months, twice a year - emphasizes a multidisciplinary approach to the various aspects of rice varietal improvement; each participant from a particular discipline is expected to better understand the role and importance of other disciplines in a team approach to varietal improvement.

396. The INSFFER Training Programme - four months - intends to increase the capabilities of the participants both in theoretical and practical aspects of fertilizer use, biological nitrogen fixation and common experimental techniques. An intensive course on Azolla and soil microbiology is also included.

397. Integrated Pest Management Course (IPM) - 3 1/2 months - prepares the participants to design, organize and implement the integrated pest management concepts at the farmers' level. It is a comprehensive approach to pest control based on ecological principles to stabilize yield at high level, to protect the environment and to maximize profitability to the individual farmers.

398. The Irrigation Water Management Training Course (IWMT) - six weeks - is designed to train the participants to recognize the factors for improving the performance of irrigation systems, including water management,
soils, agronomy, socio-economy and communication factors. Field exercises are also included as part of the training.

399. Agricultural Engineering Training Course (AEC) - two weeks, twice a year - is to acquaint the participants with IRRI's farm machinery programmes, including design, manufacture, and field evaluation of IRRI-designed machines. Classroom lectures, practical shop work, field work and maintenance are given.

Postdoctoral Appointments

400. The postdoctoral fellows, especially the senior ones, bring to IRRI special skills and experience, useful to the Institute's overall research programme. On the other hand, IRRI provides them with excellent research experience in their particular field of interest. The topics of research are oriented towards basic research, but still of a mission-oriented character. Moreover, exposure towards the interdisciplinary approach of problem-solving is of significant benefit to them after returning home.

Conferences

401. The objective is to bring together leading scientists from developed and developing countries to enable them to exchange views and information and to assess the knowledge that is available in a specific area. Collaborative plans for joint research may be developed with national scientists on problems of common interest.

402. The International Rice Research Conference - Attendance is about 150 principal rice researchers, to discuss progress and joint planning for future collaboration.

403. Symposia - Attendance is about 70 scientists, to review the status of achievements in certain areas, such as "Pests and Rices", "Nitrogen and Rice".

404. Conferences - Attendance is about 50 scientists, to review some broader topics such as rice pest control, water management, etc.

405. Workshops - Attendance is about 30 scientists, to develop collaborative plans on special problems such as rice blast, etc. Workshops are sometimes organized outside IRRI to visit specific site environments, such as "Tidal Swamp Rice" (Indonesia), "Deepwater Rice" (Bangladesh, India, and Thailand) and "Blast and Upland Rice" in Brazil.

Means - Personnel, Facilities, Sites

406. The training courses are held at IRRI, where accommodation, laboratories, experimental farm and recreation facilities are available. Practically all senior and junior scientists of IRRI give lectures in the training courses. Some of the scientists also serve as advisors to the trainees on specific topics. For example in the GEU Training, 21
GEU scientists present 34 lecture topics, while 47 junior researchers also give lectures or briefings on techniques and methodologies. In the Rice Production Training Programme about 35 scientists, both senior and junior, present the course.

**Main Achievements**

407. Information concerning the participants of IRRI's training activities during the period 1976-81 are summarized in Tables 5, 6, and 7. From year to year the participants have been increasing in numbers in almost all the training programmes.

408. The overall impact of the training programme is noticeable in the significant increase in strength of the national research institutions and their rice programmes. The alumni are self-confident, enthusiastic and highly motivated to conduct research in their respective fields.

409. The achievements of the various symposia, workshops and conferences are evident from the increasing collaborative activities of scientists in developing countries and at IRRI to work in fields of common interest. The currently existing networks for rice genetic testing (IRTP), cropping systems (ACSN), soil fertility and fertilizer efficiency are some of these collaborative activities.

410. The various kinds of conferences sponsored by IRRI dealt with very important topics. For example, to better cope with the brown planthopper problem, leading scientists from developed and developing countries reviewed various aspects of this problem in 1977 at IRRI, as a result a collaborative programme was agreed to.

**Constraints**

411. As far as housing facilities, laboratories, experimental fields, and staff hours' allocation are concerned, IRRI has nearly reached the saturation point. Under the present crowded conditions a maximum of about 200 trainees can be accommodated.

412. Communication with many IRRI alumni is difficult to maintain after return to their home countries.

413. In the GEU training programme the educational background of the trainees is very heterogenous, ranging from high school graduates up to the Ph.D. level.

414. Another constraint is the language difficulty. More than 50 % of the trainees do not have proficiency in English. This might cause some delays in the time schedule of the training session.

415. The number of participants attending each course varies. Late arrival of some of the trainees at IRRI is also one of the constraints.
Table 5: Distribution of Research-Oriented Scholars and Fellows at IRRI by Field of Specialization, 1976 - 1981

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Table 6: Number of Participants in Formal Training Courses, 1976 - 1981

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Table 7: Number of Fellows/Scholars who completed Training at IRRI, 1976 - 1981

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B. Formal Training Programmes (All participants completed training except one GEU participant in 1981.)
416. With the existing facilities at IRRI there are no serious constraints to conduct the various conferences, provided the number of attendees and the frequency of such conferences do not increase. For most conferences at IRRI special project funding should be made available to enable participating scientists from developing countries to attend. Holding conferences outside IRRI would involve considerable logistic difficulties.

Discussion of Priorities and Future Plans

417. The needs of the respective countries for certain types of training, the existing limited physical facilities, and the available research staff and technicians instructing in the courses should determine the size and extent of the training programmes of IRRI.

418. As the national research institutes are gradually becoming stronger, it is anticipated that they will be able to conduct certain training programmes themselves, for example in rice production and cropping systems. IRRI should assist them in organizing and designing the courses and the experiments, and provide them with teaching aids.

419. The kind of training IRRI should provide is "training the trainers" with more emphasis on methodologies. The GEU, INSFFER, Water Management, Engineering and Integrated Pest Management courses should be continued.

420. The degree training programmes (M.Sc., Ph.D.) should continue and be adjusted according to the needs taking into account the number of persons from various countries already trained. Priority should be given to those countries which have benefitted the least from IRRI training programmes.

421. The postdoctoral fellows' training should also continue to the benefit of IRRI's core research, meanwhile, they should be given excellent research experience. Both basic research as well as interdisciplinary mission-oriented research should be assigned to them so that they will be better prepared to do their job in their respective countries.

422. In the future IRRI will continue to sponsor the annual International Rice Research Conference. As the rice research programmes in developing countries continue to expand increasing numbers of attendants are expected. IRRI will also be sponsoring one or two major conferences each year on certain important topics, and when the need arises, to review available information as a basis for planning a joint research project on the relevant topic.

Conclusions and Recommendations

423. In spite of the constraints IRRI had to face during the last few years, the achievements of the training programmes are very satisfactory
(Tables 5, 6 and 7). Training programmes have been extended and adjusted following the suggestions of the first Quinquennial Review.

424. The course and methodologies are designed in consultation with national programme leaders so as to take into account the needs of the countries.

425. To maximize the impact of the training programmes and of the research output, the Panel recommends that:

(i) The time allocated by research staff and research assistants to teaching should not jeopardize the research performance.

(ii) Research scientists from developing countries should be posted at IRRI for a certain period of time (6-12 months or more) to expose them to new ideas and to give them an opportunity to carry out research of a more basic nature relevant to the research programme in their home country; not only Ph.D.'s should be considered but also those having M.Sc. degrees. At present there are still relatively few people with Ph.D. degrees in developing countries who are actually involved in rice research.

(iii) Other leading national universities should be considered for participation in the degree training programmes. At present IRRI collaborates with UPLB and Cornell University for degree training. The increasing enrolment at UPLB limits admission of foreign students to the University.

(iv) More attention should be given to Latin American and African countries in the training programmes of IRRI with appropriate arrangements to take into account the language problem and other difficulties.

(v) In view of the fact that qualified agricultural economists are very scarce in Asia, a degree training programme (Ph.D.) in agricultural economics related to rice should be facilitated by IRRI.

(vi) Symposia, conferences and workshops should be organized as frequently and covering as wide a variety of topics as in the past few years. However, some additional gatherings to deal with unforeseen problems, should be allowed for.
Chapter VI. SUPPORT PROGRAMMES AND FACILITIES

426. To implement IRRI's responsibilities much institutional hardware and software are needed. The present chapter deals with the institutional hardware: the station and its buildings; the library, documentation and information services; the sophisticated equipment, such as the phytotron, computers, electron microscope, and so on.

Background and Objectives

427. A large institution such as IRRI with all its international affiliations relies heavily on its support programmes and facilities. This heading covers a rather diverse group of items. The Panel has examined only some items of this group and the examination varies in depth. Other items, such as accounting, were beyond the Panel members' competence. Therefore, only selected items are discussed in this chapter.

428. A few general remarks are pertinent. With the increase of the sophistication in research necessary to tackle the more complex problems, the demands on services, equipment, and budget become more specific and more exacting.

429. Many of these demands are fully justified in view of IRRI's mandate in its third decade. This is particularly true for the handling of the continuously accumulating data from field and laboratory, which have to be processed by increasingly sophisticated methods.

430. IRRI has responded well to the recommendations of the first Quinquennial Review. (i) A rice germplasm storage and laboratory facility has been built. (ii) New greenhouses and screenhouses have been added, though less than needed due to budgetary constraints. (iii) Computer facilities were installed (ref. paras. 456,457).(iv) A 32-bedroom dormitory and twelve postdoctoral apartments have been constructed. (v) The Information Service facilities have been expanded considerably.

(a) Library and Documentation Centre

Objectives and Means

431. The library strives for completeness with respect to rice literature and for adequate coverage in the disciplines relevant to IRRI's mandate. The library organizes translation services, current awareness services, and specific-subject bibliographies. The library assists national programmes in library organization and management and in selection and acquisition of materials.

432. The Panel was pleased to see that the library was well-staffed, well-housed and well-managed. Storage capacity is adequate for IRRI's third decade.
Main Achievements

433. Some 58,000 monographs and 2,500 serial titles are registered. Several volumes of the "International Bibliography of Rice Research", "International Bibliography on Cropping Systems", the "International Bibliography on Azolla", and "Theses and Dissertations on Rice ... " have been published. The 1980 edition of the "International Bibliography of Rice Research" has been computerized. Exchanges take place with some 400 libraries all over the world. Current awareness services are rendered to IRRI off-campus staff and others.

Constraints

434. No major constraints have come to the attention of the Panel. For computer services see paras. 456, 457. Storage facilities are no constraint yet. They may become so in the 1990s. As scientists mainly use the last ten annual volumes of serials, these must be in user-accessible storage. Older numbers can be stored otherwise, e.g. on micro-fiche. The Panel suggests that the possibilities of modern efficient storage systems be explored before the library becomes congested, so as to avoid future requests for additional building.

Recommendations

435. The Panel recommends that consideration be given to the protection of unique holdings such as departmental records and rare publications against fire and other dangers by copying them on micro-fiches and storing these copies elsewhere.

436. Because of the possibility of obtaining a better penetration of IRRI publications in regions not using English as a vehicle of scientific interchange the Panel suggests the establishment of an abstracting service producing abstracts from IRRI publications in various languages.

(b) Information Services

Background and Objectives

437. The Information Services Department disseminates information on rice and related subjects, especially to developing nations. The department participates in all teaching activities of IRRI by carefully designing and printing written materials. The department has specialized in the production of audiovisuals.

Means - Personnel, Facilities

438. Personnel. In view of the swelling stream of materials offered for publication the editorial staff becomes a limiting factor. Visiting scientists and editors take a large share of the preparation of teaching materials including self-instructional slide-tape units.
439. Facilities. The available space is adequate and fully utilized. There are no major constraints in processing equipment. Major assets in streamlining the operations include two computerized word-processors for keyboarding and editing of manuscripts, and a compatible phototypesetter that converts the keyboarded text of the word-processors to type-set gally proofs, ready for layout.

Main Achievements

440. The Panel is highly impressed by the efficiency and productivity of the Information Services Department and the quality and skills of the staff.

441. During the quinquennium under review a long list of publications has been printed, with 3,000 to 5,000 copies initially printed for each major book and 8,000 to 15,000 copies for each periodical. Among them were 50 major book titles. The International Rice Research Newsletter, with 15,000 copies per issue, seven issues per year, is a major publication outlet for rice researchers in developing countries and an important vehicle of information on rice. The IRRI Research Paper Series established in 1977, now publishes about 20 issues per year, 8,000 copies each. The publication of the Research Highlights and the Annual Reports within one year delay is an indication of superior organization, and the quality of these reports is highly commendable.

442. Over 60 audiotutorial modules (slides, tapes, booklets) have been completed; they are in great demand. Six books have been translated into 18 languages. Special efforts are made to make illustrations in teaching material self-explanatory and to keep the text simple for easy translation. Printing negatives are released to national programmes on request and without charge.

Constraints

443. Editorial time is becoming a major constraint, because: (i) more and more material is offered for publication; (ii) more general information for a non-scientific audience is required, which ultimately may contribute to IRRI's sustenance but which is time demanding; and (iii) more requests for in-service training.

444. The editorial staff feels the need to spend more time on training (three M.Sc./Ph.D. students trained up to now) but has no time to do so.

445. IRRI tries to alleviate the pressure on the editorial staff. (i) A Publications Screening Committee assesses priorities. (ii) Joint publications with commercial companies are considered, in which the companies will commercialize hard-bound copies in developed countries and IRRI will distribute paperbacks to developing countries at considerable discount. (iii) Proceedings of IRRI meetings could be reduced to selected papers and interpretative analyses; the latter tend to transfer the workload to the IRRI scientists involved. (iv) By placing word-processors...
in the various departments, keyboarding can be moved to the scientists directly involved.

Discussion of Priorities and Future Plans

446. The Panel considers the Information Services to be an essential component of IRRI's core programme. The Panel endorses IRRI's policy to alleviate the pressures on the editorial staff.

447. The Panel considers the training component to be so important that it suggests a reassessment be made of the staffing needs.

448. The Panel suggests that the printing of maps be contracted to specialized agencies.

Conclusion

449. The Panel is highly satisfied with the output of the Information Services and makes no formal recommendations.

(c) Station Management and Maintenance

450. The Experimental Farm comprises 296 ha. In 1980 about 179 ha were prepared and planted on the lowland part and some 90 ha were readied for planting in the upland part. Some 14 ha are planted with breeding materials (120,000 selections per year) and some ten ha with germplasm material (ref. para. 57).

451. Land is assigned to the various departments. Work is assigned by the Farm Manager upon request of the departments. The equipment is pooled under the supervision of the Farm Manager. Ample use is made of contract labour.

452. There are two notable constraints. (i) Provision for upland rice are far from representative; the acquisition of land as a permanent solution has not yet been successful. (ii) Pests and diseases have attained such a high level on the farm that multiplication of gene bank accessions is endangered. IRRI has alleviated the situation by renting some four ha of land elsewhere, but is still looking for a more permanent solution.

(d) Buildings

453. The Panel thinks that the buildings are well designed and utilized. In view of the budgetary constraints expenditure for standard maintenance has been reduced during the last few years. The Panel wants to stress the necessity of an adequate level of maintenance of buildings, especially in a tropical environment.
The Panel wants to put on record that the Directorate raised the question of an amortization and replacement fund, a question which needs consideration at the appropriate administrative level.

The Panel was told that some of the screenhouses were in bad repair and that the total screenhouse area was insufficient in view of the justified demands of the plant breeders (ref. para. 229).

(e) **Computer Facilities**

**Background and Objectives**

Computers, be they large units, minis or micros, have become a normal tool in research and administration. IRRI has access to the IBM 370/135 computer of the Agricultural Resources Centre (ARC). The computer was donated by IBM in 1980. Operating costs are shared among IRRI and other Los Banos users.

The Department of Statistics has a Wang 2200 mini-computer (24K) with many peripherals. Each of the Department of Economics, Agricultural Engineering and Water Management has a micro-computer TRS80 (64K). The Multiple Cropping Department has a 16K Hewlett Packard micro-computer.

The recommendation by the first Quinquennial Review to speed up the acquisition of a computer has been implemented by IRRI, but the facility has now become inadequate (ref. para. 460). IRRI has installed a Computer Committee to discuss and coordinate computing activities.

**Main Achievements**

Plant breeders, economists and statisticians are major mainframe users. The Germplasm Bank, IRTP, the International Rice Genetic Survey, and the Farm Record Keeping require large data storage and retrieval facilities, as does the project to computerize the International Bibliography on Rice Research.

**Constraints and Future Plans**

The present mainframe computer presents a serious constraint to any progress in scientific and administrative computing. It is used to full capacity, is batch processed, and has only two interactive terminals which are sparsely accessible. On-line operation is possible two hours per work day. Turn-around time is long. Interactive processing, necessary in modern scientific work, is hardly possible.

IRRI has devoted considerable attention to the overall computer problem, hoping to have a large computer donated to the Institute. External consultants' reports are available which support the need for
a large computer. Should a mainframe computer be donated to IRRI, its computer problems would be resolved for the near future. If IRRI cannot find a donor, the Institute should rely on other sources.

462. Computerization of the administrative work is evidently unacceptable in view of the present constraints. Computerization will, however, improve the administration, especially in the reconciliation of IRRI's many banking accounts, the management of cash flow, and the maintenance of inventory records. Rapid turnover adds to the administration's efficiency. Remote terminals for word-processing will alleviate some of the pressure on the editorial staff of the Information Services. Efficient and rapid literature retrieval is possible only by interactive access to the computer files containing the International Bibliography of Rice Research. Part of the workload can be passed from the Librarian to the requesting scientist.

463. An important constraint seems to be the lack of awareness among part of the scientific staff regarding the full utilization of a computer. Among the many possibilities, techniques such as data base management, multivariate analysis, dynamic systems modelling with high-level computer languages, and computerized mapping procedures, will be of interest to some departments.

Discussion

464. The Panel concludes that IRRI should not postpone the acquisition of a computer, be it by donation, purchase, lease, or rent.

465. The Panel concludes that, the case of donation excepted, the issue on numbers and sizes of computers, types, remote terminals, and other requirements has not yet been settled. The Panel urges IRRI to go deeply into these issues, to provide the senior staff with sufficient information on possible uses of the computer, if desirable by hiring short-term consultants (representing computer users rather than computer specialists) to list future user requirements after receiving information from the staff.

Conclusions and Recommendations

466. The Panel suggests to increase the awareness of the IRRI scientists with respect to computer utilization and future users' needs. The Panel recommends that IRRI acquire adequate computer capacity, by donation or otherwise, after due inventory of future requirements of scientists, library, information services, and administration.

(e) Equipment

Background and Objectives

467. Sophisticated equipment is a necessity in modern research. Nobody doubts the usefulness of the phytotron at IRRI, used by some seven depart-
ments for a variety of studies, notwithstanding the fact that a phytotron is expensive, requires intensive servicing, and consumes much energy. The mass spectrometer, used to study the fate of labelled nitrogen, and the liquid scintillation counter are also sophisticated pieces of equipment that have helped to produce research data that could not be obtained otherwise.

468. With judicious purchasing, maintenance is no unsurmountable problem. The IRRI maintenance team has performed remarkably well, though periodic servicing by specialists cannot be fully excluded. Nevertheless, some older pieces of equipment approach replacement time, and budgetary provisions have to be made. Others should be acquired to keep research up-to-date.

**Phytotron**

469. The phytotron, donated by Australia at a cost of US$ 1.4 million and dedicated in 1974, is an outstanding facility, in good condition and working well. It has a gross area of 1,040 m² with 132 separately controlled growth areas totalling 275 m², and specialized rooms and equipment for various supporting activities. The phytotron also houses the facilities for tissue cultures, including laminar airflow cabinets, a light room and a dark room.

470. Apart from the officer-in-charge, who is one of the senior scientists, the following personnel is assigned to the phytotron: two engineers, four electrical/mechanical technicians, two biologists, one laboratory aide and one secretary. The technical personnel operates in three eight-hour shifts a day, so that the phytotron is continuously serviced. Maintenance costs surpass US$ 200,000 of which 50 % is for power supply.

471. The phytotron is in use for over forty research projects per annum, with occupancies varying according to the type of facility from 69 % to 91 % (ref. para. 229).

472. The Panel considers the phytotron to be an excellent facility, in which work is done highly relevant to IRRI’s mandate. It is well managed, well serviced, and it has a high occupancy sometimes up to the practical maximum, although some of the uses of the phytotron can be taken care of in screenhouses. The Panel suggests that timely preparations begin for the replacement of the artificially lighted reach-in plant growth cabinets as these are approaching the end of their expected lifespan; replacement can be staggered.

**Electron Microscope**

473. A transmission electron microscope is indispensable for certain types of research. As stated in Ch. III, virological research has been retarded considerably by the lack of a transmission electron microscope needed for isolation and identification of virus particles. Other disciplines will profit from the availability of an electron microscope. Among these are mycology and plant physiology (chloroplast studies in relation to productivity), possibly also soil science.
474. Purchase of an electron microscope implies availability of space, power and personnel to work with it. IRRI assured the Panel that these were available. Also, ancillary equipment must be procured, such as equipment for embedding and metal shading, and an ultramicrotome. Personnel has to be trained in the usage of this equipment.

475. The Panel has found that it has been impractical for IRRI to utilize an electron microscope of a national institution and the Panel is convinced that IRRI must have its own electron microscope. The Panel recommends that IRRI assign a high priority to the acquisition of a transmission electron microscope and ancillary equipment.
Chapter VII. MANAGEMENT AND ADMINISTRATION

476. Whereas the foregoing chapter dealt with the institutional hardware, this chapter discusses institutional software. This comprises governance and management. The functioning of the Board of Trustees is discussed. Some overall aspects of management, administration, personnel policy, and finance are reviewed.

(a) Governance and General Management

477. The IRRI is administered by a Board of Trustees whose membership and procedures follow the general principles of governance of the IARCs. The 15 Trustees now include the Minister of Agriculture of the Philippines, the President of the University of the Philippines, representative(s) of the Ford and/or Rockefeller Foundations and the Director-General as ex-officio member and other members selected in their personal capacity from major rice producing countries and/or donors to IRRI. These members are selected and elected by the Board itself for a four-year term with a recently established provision for a second four-year term in order to ensure more continuity in the guidance of the Institute. The Chairman is elected each year from the membership, but so far the turnover in Chairmanship has been limited and there has been therefore continuity in the guidance of the Institute.

478. The Board normally meets twice a year, once at IRRI headquarters and again in a major rice producing country. The formal meetings are rather short (usually two days). A wide range of subjects is discussed regularly such as the reports of the Board’s Committees (see below), the programme accomplishments, the programme and budget, and various administrative matters; others deal with special problems or programme elements which the Board decides to examine in more depth. The short duration of the meetings has been compensated for recently by an increase in the number of subsidiary committees of the Board and by the opportunities for informal discussions during the tours which were organized for the Trustees in diverse Asian countries in conjunction with the Board meetings (India, Indonesia, China, Thailand).

479. There have been considerable changes in the mode of functioning of the Board during the last three years. Before the establishment of the CGIAR, the Board relied on the Foundations for the financial and administrative review of the Institute and had mostly an advisory role.
in the general direction of the programmes and other technical matters. The approval of the programme of work and budget was a simple formality and the Board was not involved in the general review of the management of the resources of the Institute. This arrangement persisted when the CGIAR system was established and continued with the first phase of the overall expansion of the IARCs.

480. The Board gradually changed its role and procedures over the last three years for several reasons. The guidance of IRRI became more complex as the size of its programme and budget and the geographical spread of its activities increased. At the same time, the CGIAR donors questioned the rationale for the continuing rapid growth of the Centres—in particular the older ones—and stressed the importance of the responsibilities and obligations of the Board of Trustees as regards their accountability for the efficient use of the resources provided by the donors.

481. As the Board decided to exercise its responsibilities more fully, several matters were identified, requiring particular attention. Some of these questions were referred to the existing standing committees of the Board, the Executive and the Programme Committees. For example, the Programme Committee was requested to attend the annual internal reviews and report on its comments to the Board. An Audit Committee was established. Another Committee was requested to examine the personnel salary scales and the modes of compensation. The Board requested that more information be submitted by the Director-General on the appointments of new senior staff and on the special contracts or projects undertaken by the Institute, and asked that these be formally approved by the Board, especially as regards the heads of departments and important special projects. The Board also requested and discussed special reports on selected parts of the programme.

482. The impact of these developments is briefly discussed in other sections of the report, in particular as regards administration, programming and budgeting. At this stage, the Panel merely wishes to give full support to the action which the Board has taken in order to assume its responsibilities more fully within the limits set by the basic texts of the Charter and By-laws of IRRI. The Panel having itself experienced the difficulty of reviewing the work of large and complex institutions of high scientific calibre such as IRRI, fully supports the trend by which the members of the Board are endeavouring to get a fuller understanding of the activities and problems of IRRI as well as being fully informed of important developments in the CGIAR system. The Panel also considers that the steps taken by the Board as regards its overseeing of the use and management of Institute resources will enhance the confidence which the donors have in the high quality and efficiency of the activities of IRRI. The Trustees on their side should be prepared to devote as much time as necessary to the Board business, especially when special circumstances require it (financial stringency, change in management, possible priority shifts and reorganization as a result of the long range plan of IRRI for the third decade and of this Quinquennial Review).
The organizational structure of IRRI is at present under review by a team of management consultants. The former organization was characterized both by great flexibility and trust and by a strong leadership and in-depth involvement of the Director-General in the management of the diverse units of the Institute. Pending the appointment of the new Director-General, responsibilities have been shared within the Directorate of the Institute which is comprised of a Deputy Director-General (International Cooperation) - Acting Director-General, a Deputy Director-General (Core Research Programmes), a Director (Research and Training Coordination), and a Director (Administration). At the same time some decentralization and delegation of responsibilities took place during this interim period.

The Panel was informed that different organizational charts were under study by IRRI's management consultants. It does not consider it appropriate, however, to advise on the organizational structure which the Institute should take in the future, knowing that much will depend on the style of management of the new Director-General and on the consideration of the senior staff concerned when selecting among diverse alternatives.

The Panel, however, considers it important to draw the attention of the Board and the management of IRRI to several points:

- The growing development of off-campus activities, collaborative work and sabbatical leaves may require frequent absences of the directing staff at all levels. It is therefore important that the new structure provides for clear lines of command and delegation of responsibilities.

- The multiplicity of the departments and the interdisciplinary nature of the entire programme have led to the development of a "matrix" system of management which seems to be efficient, flexible, and successful in terms of programme output and staff involvement in responsibility sharing. It could become cumbersome for the management and monitoring of the programme, and confusing in the identification of responsibilities, if the number of problem areas and programmes continues to grow across departments. To the extent feasible and without changing the interdisciplinary nature of the programmes, an effort should be made to identify more clearly the main responsibility for each problem area and each programme with a specific individual.\(^1\) At the same time, the number of programmes and problem areas should be reduced wherever possible.

\(^1\) This individual may be appointed for a determined period and may not necessarily be a department head.
Programme Formulation and Implementation

486. The responsibility for programme formulation and implementation rests with the Directorate of the Institute, whereas the Board has the powers and duties to formulate policies guiding the programme, to review and approve the programme and budget requests submitted by the Director-General, in the light of its policies, and to monitor concurrently the progress of the Institute and its financial situation.

487. Until 1980, the process of programme preparation was relatively simple. The programme was formulated after the annual internal review of the accomplishments of the past year and discussion of the proposals of the departments. Initially the internal review lasted one week involving all the scientific staff of the Institute and some outside consultants or resource persons selected in their personal capacity. As the programme expanded, the internal review was extended to two weeks, and since 1980 members of the Programme Committee were requested to attend the internal reviews and report their comments and recommendations to the Board. Moreover, the Board requested that each year certain segments of the programmes be placed on its agenda for a fuller discussion.

488. These developments should give members of the Board a better awareness of the programmes and enable a better policy guidance in setting priorities. The Programme Committee should pursue its analysis of the programmes and continue to make detailed comments on their implementation and impact and recommend appropriate changes in the objectives, structure and contents of the programmes, as necessary.

Programme and Budget Documents

489. An important effort was made for the Second Quinquennial Review in defining the objectives and future plans of the Institute as a whole, of each problem area and programme. This effort should in the future be reflected in the programme and budget documents of IRRI by giving not only the objectives but also short narratives of the work plans of the main programmes on a two-year basis. The programme and budget document should also give information on the implementation of the long term plan and on its adjustment in the light of accomplishments and new problems.

(c) Administration and Personnel

490. An excellent analysis of the personnel management was made in the First Quinquennial Review report. The Panel concurs with the findings of this analysis. Only important points and new developments are reported here.

1/ Programme Committee members were invited to attend internal reviews in the past but only few of them participated. The long duration of the internal reviews remains a problem and the Programme Committee may wish to examine only part of the programme each year.
The last five years were characterized by a considerable increase in the workload of the administration. The number of employees, buildings, housing facilities, and the size of the budget increased by about 100% during this period. The off-campus activities also increased as indicated in Chapter V. In the meantime, a number of steps were taken for the improvement of management and administrative procedures. As a result, there was a relatively small increase in administrative personnel. The percentages of the administration and general operating expenses remained almost constant during the last five years as compared to the total core budget of the Centre.

The total staff of the Institute is now close to 2,000. In addition, IRRI employs 400 persons for casual labour. A programme for professional improvement and career development of the local personnel was started. Their conditions of employment were categorized, elaborated and standardized, and IRRI now has, for the local staff, a manual for personnel regulations and a handbook for use by the newly recruited personnel. IRRI keeps track of the employment conditions in the Philippines and abroad, for the local personnel and the international staff respectively, by means of wages and benefits surveys so as to remain competitive in the employment market. As regards the local staff, IRRI was classified as the second best employer in the Philippines. The conditions of employment for its international staff are comparable to those offered by other Centres although they may not be the best as regards some benefits and this was reported to have recently caused some difficulties in recruitment.

Procedures of evaluation were elaborated and implemented for the local staff. The quality of the staff is generally excellent and IRRI is fortunate in recruiting and retaining staff which is skilled, eager to work and to improve its performance for the Institute. These procedures of evaluation help in the career development of the local personnel. No similar system of personnel regulations and evaluation exists for the international staff as yet. The Panel agrees with IRRI that such a system is difficult to develop and implement. It considers that it is more important that close and frequent communication between the staff and the Directorate continues to be maintained so as to provide ample opportunities for staff evaluation and guidance in career development.

The Panel expresses particular concern for one of the categories of IRRI staff: the personnel in the off-campus activities. Most of them are not core staff and work on fixed term contracts and are not considered as members of a specific Institute department. The Panel noted that some of this staff feel isolated and insecure in their career prospects with IRRI - they would wish to participate more fully in the formulation, implementation and review of the programmes at headquarters (in particular by participating in the Annual Internal Review) and maintain sufficient contacts with colleagues in their scientific disciplines. These concerns appeared legitimate to the Panel including those related to granting sabbatical leave to off-campus staff under certain conditions. The Panel wishes to draw the attention of the Board and of the management to these problems of professional development, tenure and career of the off-campus staff. The Panel recommends that
the Board and the Directorate of IRRI give immediate attention to the problems of professional development, tenure and career of off-campus staff.

495. The Panel is pleased to confirm that the high standards of the scientific and managerial personnel which had been praised by the first Quinquennial Review have been maintained. It also noted with satisfaction that, as recommended by the first review, some interchange of personnel between headquarters and off-campus programmes, and between IRRI and nationals of developing countries has taken place. This interchange should continue and be expanded. The first Quinquennial Review made several recommendations which continue to deserve urgent attention, particularly those regarding the evaluation of the senior personnel and the terms of employment of off-campus personnel.

496. The senior staff positions of IRRI increased in numbers from 48 to 59 and the fill rate also increased concurrently from 92% to 97% from 1976 to 1981. The turnover in senior staff from developing countries was relatively low as compared to that of the staff from developed countries. IRRI should strive to maintain the international composition of its senior staff.

497. IRRI also hosts a comparatively high number of visiting scientists, postdoctoral fellows and staff of collaborative research projects. They are of very diverse nationalities and by the very nature of their assignment have a high rate of turnover, although they also constitute an important source of recruitment for the regular staff after a selective probationary period. Their presence significantly increases the research capacity of the Institute and brings new ideas, methods and findings. The Panel fully supports the policy of IRRI in this respect which together with the provision of sabbatical leaves for the core senior staff enables the Institute to maintain its vitality and remain at the forefront of research in its field.

(d) Finance, Supplies and Related Services

498. IRRI took a series of miscellaneous actions on a wide front which generally increased its cost efficiency and accountability during the last five years. Significant savings were made on energy expenditures, vehicle and equipment purchases, and construction costs. Several important security measures were taken which enabled a reduction of the insurance premiums paid by IRRI. Special procedures were introduced to reduce costs of air travel by competitive travel ticketing. Some of the savings so effected enabled the construction of additional facilities.

499. The accounting procedures were also improved and an internal auditor was appointed, reporting directly to the Director-General. The Panel was informed that the ongoing management audit was likely to lead to the introduction of other improvements in particular as regards the streamlining of administrative and accounting procedures, the monitoring
of the expenditures, fund management, the controls of the inventory of equipment and the use of supplies and other expendable items.

500. The Panel was pleased to note that there has been an increasing awareness among the staff for cost efficiency at a time of general financial stringency. The Panel was informed that with the planned acquisition of a computer, several administrative procedures and controls would be computerized. The Panel expressed the wish that computerized administrative and accounting procedures should be introduced carefully with the objective of facilitating the work of the scientists rather than complicating their administrative burden in filling out multiple forms with complex coding systems.

501. The Panel recognized that since 1980 vigorous steps have been taken by the Board and the Directorate to improve administration and accounting at IRRI with a view to further increasing cost efficiency. It is understood that further important measures are being considered in the same direction which the Panel fully supports.
Chapter VIII. GENERAL ASSESSMENT AND IRRI'S THIRD DECADE

502. In this chapter the Panel attempts to bring together its main findings and place them in perspective with the plans of IRRI for its third decade. In the preceding chapters the objectives, achievements, constraints and future plans were reviewed individually for each programme. When considering the Panel's observations as a whole in the context of the changing needs of developing countries in terms of rice production and of the development of their own rice research capacities, some of these observations deserve particular emphasis in the overall assessment of IRRI's work and plans for its third decade.

(a) Preliminary Remarks

503. The Panel notes that the "Plan for IRRI's Third Decade" was presented with the agreement of the Board of Trustees as "A Proposal for Discussion with the Quinquennial Review Team". The Panel therefore intends to relate its conclusions to this plan with the understanding that this document was to be considered as a discussion paper and will probably be further elaborated.

504. At the outset, the Panel wishes to congratulate IRRI for the clarity of the document and for the major effort which was made in condensing and structuring a considerable amount of findings and thoughts, which emerged from the multiple activities of the Institute over twenty years and from the many ideas received from the staff and the collaborators (including those which were presented at the IRRI conference on "Rice Research Strategies for the Future" held in April 1980). This long term plan document was most helpful to the Panel in particular as regards the clear statements of objectives, priorities and strategies of IRRI, presented at the beginning of the document and for each of the research areas and cultural types. The Panel wishes to present some general observations on the approach and format used in this plan before entering into further discussion of its contents in the following sections.

505. IRRI made a valuable effort in attempting to quantify the diverse elements of value judgement which are brought to bear in the development of a long term plan for an institute such as IRRI. A methodology for rating and combining these elements was developed and helped in defining the priorities. Speculative thinking can be structured in a more orderly manner in this way but the exercise remains a perspective study based on value judgement applied to an ensemble of data and information of varying reliability. The role and impact of international research as related to those of national research and of other national actions required for improved rice production development (extension and delivery services, price policies, investment) are difficult to assess separately. IRRI also sought the best judgements of competent persons engaged not only in research but also of those involved in development and particularly
those of the developing countries. This should remain the major foundation for the long term planning exercise of an international institute such as IRRI.

506. In spite of the above difficulties, this long term plan should prove to be an essential instrument for those involved in the governance and management of IRRI, for the donors and those who cooperate with IRRI in diverse ways. It is therefore important that the document gives a clear understanding and justification of the goals and mode of operation of the Institute.

507. The Panel wishes to comment on the aspects of the long term plan of IRRI relating to the staffing, resources and budget implications presented at the end of the document. The rationale for selected incremental additions in the staff is given on a case-by-case basis and therefore is difficult to relate to the preceding chapters which take a much broader perspective in the presentation of the future plans. The Panel presumes that the circumstances probably justified this pragmatic but narrow approach in looking at some specific staff requirements of the Institute. The Panel recommends however that IRRI provide a broader analysis of the past and present resource use as a basis for a more comprehensive presentation of its future needs.

(b) Review of IRRI's Main Achievements and Deficiencies (1976-1981)

508. The report of the first Quinquennial Review discusses in its introductory chapter the difficulties of measuring the achievements and impact of an international agricultural research centre such as IRRI. While these general considerations will not be repeated here, it is important to stress that this Panel experienced some of the same difficulties as the first Quinquennial Review Panel, but could use the assessment made in 1975 and the other recommendations of the first Review Panel as background reference.

509. At the outset, the Panel wishes to stress that the recommendations of the first Quinquennial Review have been taken in due account by IRRI, with few exceptions which will be discussed in the following sections of the chapter. During these last five years IRRI's programme continued to be highly productive and dynamic not only at headquarters but particularly in the off-campus activities and collaboration with national programmes.

510. When reviewing the accomplishments of IRRI during these last five years, the Panel felt that it should go back to the basic mandate and goals of the Charter of IRRI and measure the output and impact of IRRI's work against these goals. One of the major positive developments is that IRRI's cooperation with national programmes has become closer and so helpful in promoting a wide range of national initiatives in agricultural research and development that it is increasingly difficult to identify and assess IRRI's achievements against the basic objective of increased rice production, improved nutrition and welfare in rural areas separately from the achievements of national programmes. The Panel therefore decided
to assess IRRI's accomplishments in terms of the main categories of programme outputs of an IARC, namely: (i) the development of improved technologies, their adoption and impact; (ii) the creation of new scientific knowledge and its dissemination; (iii) the contributions to the strengthening of national rice programmes in less developed countries; (iv) the collection and distribution of germplasm. In doing so, the Panel also attempted to identify the areas where IRRI retains significant comparative advantages. It also reviewed some aspects of its performance and efficiency as regards its mechanisms of governance and management.

The Development of New Technologies, their Adoption and Impact

During the last five years IRRI's policy in the development of improved rice varieties was to capitalize on and consolidate the gains of the previous years in yield potential and stability by trying to extend the benefits of its breeding work beyond the irrigated areas, in particular in the favourable rainfed environments. An increased number of elements of resistance or tolerance to adverse factors of soils and climate, pests and diseases were incorporated in its breeding lines. This accounted for important gains in yield stability and in actual farmers' yields and income, mainly in irrigated areas but also in some favourable rainfed environments. As a result, IRRI's varieties and other varieties mostly derived from IRRI material are entering some of the favourable rainfed areas and areas where soil deficiencies or other adverse factors had so far restricted their use and impact. For example, IR36, released in 1976, is the most widely utilized rice variety in the world.

There are still, however, regions and countries where rice production remains stagnant and/or does not keep pace with population growth. As IRRI is moving into more difficult environments, progress is necessarily slower, because of the diversity and variability of their conditions in time and in space, in particular as regards upland rice areas and deepwater rice, where the impact of IRRI's research has been more limited so far.

Another major achievement of IRRI during this last quinquennium is the development of knowledge and technologies which should enable safer and cheaper control of several major pest and disease problems, such as the brown planthopper, tungro virus, and grassy stunt. Less progress has been made, however, in controlling some other diseases and pests, blast in particular.

The major advances made by IRRI in enhancing the impact of its breeding work are largely due to the fact that its interdisciplinary work and closer cooperation with national programmes and farmers enabled the Institute to develop "companion technologies" to the HYVs
in agronomy, pest control through resistant varieties, soil and water management, machinery, and promote more efficient methods of technology testing and delivery. These made it possible for the small farmer to derive more benefits from the use of modern varieties. Some progress has been made in the development and combination of simple machines and practices which can reduce the turn-around time between crops, make fertilization more cost effective, reduce hardship and improve efficiency in planting and harvesting operations. Several of these technologies are not new or were not developed initially by IRRI (Azolla, transplanter, reaper, etc.). The major contributions of IRRI in these cases was in the adaptation of these technologies to small farmer conditions together with a set of cultural practices, which make possible their wider adoption. Here again, the role of the testing and delivery methods promoted through IRRI's network and pilot field project was essential.

515. Another major output of IRRI's research was the development of early maturing varieties together with a set of cultural practices which allowed two or more crops of rice per year and/or an upland crop to be grown. The achievements in technology were made possible by the combined work of the agronomists, the crop protection specialists, the machinery specialists, the economists, and the cropping system group, exploiting the advances made in breeding work, together with a better understanding of the environment, of the constraints of the farmer and consequences of new technologies. The Panel considers that the advances made by IRRI and its collaborators during the last five years in developing and spreading technologies for multiple cropping of rice and associated crops may prove to be very significant in addition to those derived from the development of rice varieties. Their impact is still limited in terms of acreage but holds promises especially in view of the growing interest of national programmes. Intensification of cropping patterns brings with it a series of pre- and post-harvest problems, many of which remain to be solved in particular as regards the maintenance of soil fertility, pest control and losses during harvest and post-harvest especially in the rainy season.

516. Some of the recent accomplishments of IRRI are at the border line between methodology and technology development but should be mentioned when taking into account the interest shown by development agencies and their considerable potential for impact: the Panel noted with interest the progress made by IRRI in developing methodologies and techniques for the improvement of the management of irrigation systems. Unreliable irrigation water supply is often one of the main causes of inequity in irrigation development, and of the non-adoption of modern technologies by the farmers. IRRI has made significant advances in devising ways and means to reduce this major constraint.

The Creation and Dissemination of New Knowledge

517. The Panel wishes to underline that the technological output and impact of IRRI as briefly reported above would not have been possible
without maintaining scientific excellence in basic research and gaining additional knowledge and experience about the functioning of the rice plant, of the very diverse environments under which it is grown, of its multiple "enemies" and adverse factors, of the mechanisms controlling the efficiency of diverse inputs and management practices, and of the role of the constraints and the consequences in the adoption of new technologies. The interplay of the incremental gains in knowledge in the diverse scientific disciplines was essential in ensuring the relevance and the effectiveness of the technological output of IRRI. It also enhanced the quality and usefulness of the training programmes of the Institute, of its seminars, conferences and publications.

518. However, the major emphasis of the last years on technology output and impact on farmers' yields may have reduced the level of supporting basic research in some strategic areas and IRRI, therefore, should examine its balance between basic and applied research as it broadens its interest in the less favourable environments, with a view to maintaining its creativity.

519. Particularly significant scientific advances during the last quinquennium are in the following fields:

(i) A better understanding of crop losses induced by insects, extreme temperatures and drought; of tolerance to adverse environmental factors; of the micro-evolution of the brown planthopper; of biochemical resistance against rice pests; of the genetics of resistance against various pests and diseases; and of insect resurgence after pesticide application.

(ii) The development and improvement of methodologies for screening germplasm against important insect pests and diseases, against a variety of adverse soil conditions; for site characterization of experimental sites; for the study of constraints; for on-farm research on cropping systems and related pre-production testing.

(iii) A better understanding of the N transformation in the soil; of fertilizer N losses, and of the relationship of soil and climate with rice yield.

(iv) Problem identification and analysis including the collection and processing of survey data and statistics leading to a better priority setting in rice research and development; to the characterization of some aspects of the main categories of non-irrigated ricelands, and related environmental factors.

(v) The opening of new lines of basic research at IRRI in such fields as studies of source-sink relations and senescence in dwarf indica rice; the control of water balance of the rice plant through soil-plant-atmosphere continuum; rice host
plant/brown planthopper interaction; the role of blue green algae (BGA) in the nitrogen economy of the irrigated rice; factors affecting NH₃ volatilization from flooded rice soils; rice adaptation to toxic and nutrient deficient soil conditions.

(vi) A better understanding of the constraints and consequences in the adoption of new technologies particularly the mechanism of interaction between biological and physical constraints and institutional and socio-economic conditions; including those related to small scale mechanization of rice farms and the impact on labour and labour requirements.

520. There are however several areas where insufficient scientific knowledge is limiting the development and impact of technologies. The most important appear to be blast (genetics, epidemiology and resistance mechanisms) and soil physics.

Contribution to the Development of National Rice Research Programmes, their Cooperation and Collaboration

521. The main contribution in this field has been in the extension of training activities which were facilitated by an increase in the capacity of IRRI to accommodate trainees and postdoctoral fellows, and in the improvement and increase of the number of courses, and of the training material. The success of IRRI in this field can be measured in several ways: the number of people trained, the present saturation of its training capacity, the improvement in the quality, the extent and efficiency of its cooperative networks, and the contributions made in the building up of a rice research programme with competent scientific staff in various countries, such as Indonesia, Bangladesh and Thailand.

522. The main limitations and gaps in training are due to the magnitude of the demands, the availability of time from the senior scientists, the limited staff at IRRI working full time on training and the limited cooperative arrangements of IRRI with universities for graduate training.

523. The larger participation of countries in IRRI's cooperative networks during the last five years is also an important development, in particular as regards their growing involvement in the planning and assessment of the activities of the networks. This is also expected to promote cooperation among developing countries themselves.

524. Since 1975 there has been a significant extension of off-campus activities of IRRI in terms of cooperative projects with countries in Asia and outside. A major development has been the establishment of close cooperation with China, with mutual and reciprocal benefits in germplasm collection and utilization, development of technologies, research methodologies and new lines of research, such as hybrid rice and tissue culture. Other cooperative projects contributed to the national programme capabilities in varietal improvement, development
of cropping system research, farm machinery production and utilization.

525. Liaison activities with Africa and Latin America were established and started but collaboration with some of the national programmes and IARCs concerned developed at varying paces and was often ineffective or not even implemented.

526. Of major importance in the achievements of IRRI is the strengthening of its cooperation with national programmes (and in the provision of multiple services to them): the increased participation of developing country scientists in IRRI's seminar, workshops and conferences; the considerable output of publications of IRRI and their wide dissemination in particular the production of basic textbooks and literature reviews on certain subject areas, such as soils, rice agronomy, rice physiology, etc., as well as periodic bulletins and newsletters.

Collection, Conservation and Distribution of Germplasm

527. This is an ongoing activity of IRRI but it has been singled out by the Panel in reviewing the achievements over the last five years because of three significant developments: (i) the completion of the germplasm bank facilities and their organization as a major functional service of IRRI; (ii) the development and implementation of information systems which can provide invaluable data, not only on the origin and characteristics of accessions but also on the pedigree of existing varieties; and consequently, (iii) major increases in the demands and use of the material contained in this collection (now about 60,000 accessions) not only by IRRI scientists but also by the national programmes. These positive developments, however, create additional problems for the management and evaluation of the collections.

528. In addition, the distribution of germplasm from IRRI and from the national programmes expanded, both in terms of diversification of the nurseries and geographical coverage.

Other Achievements

529. Many other developments have been noted by the Panel in its analysis of the various programmes of the Institute. The Panel wishes to stress the particular importance of several positive developments in the role of the Board in providing closer guidance of the policies and priorities of the Institute, in the monitoring of its programme and its overall responsibility in the use of IRRI's resources. On the management side, and with the active support of the Board, a series of improvements have taken place in expenditure controls, in personnel management, in accounting and auditing, leading to better efficiency and significant savings in the operation of the Institute. This trend should enable the Institute to make additional important improvements in the efficiency of its governance and management which should further enhance
the confidence and support of donors to IRRI at a time of general financial stringency in the CGIAR system.

IRRI's Comparative Advantages

530. The important achievements reported above show that IRRI continues to maintain a significant comparative advantage for the following reasons:

(i) its very broad interdisciplinary approach in addressing the problems of improved technologies for rice by associating highly qualified scientists in a broad range of disciplines in both basic and applied research, in particular as regards GEU and cropping systems. The continued development of the GEU programme both in its interdisciplinary conceptual approach and its research activities has resulted in what is possibly the most comprehensive and dynamic breeding programme devoted to any crop.

(ii) the quality and dedication of its senior and junior scientists and of the support staff;

(iii) a set of unique research facilities and means in terms of a main station which is very well run, and has excellent support facilities and buildings, although some essential pieces of sophisticated equipment need to be acquired;

(iv) an invaluable and unique germplasm bank;

(v) scientific knowledge and very wide experience accumulated over 20 years of basic and applied research in tropical rice;

(vi) the establishment of advanced methods and techniques for rice research and for field testing and field surveys;

(vii) a wide range of fruitful collaborative relationships with rice scientists and rice research institutions in the world, particularly in Asia, which enable IRRI to keep its research focussed on practical and relevant problems, and at the same time ensure a multiplier effect to its research and training programmes;

(viii) the very large impact of its technologies in certain areas and certain countries, which has given a higher reputation to its research and enhanced the status of agricultural research in developing countries;
(ix) a training programme and information service which are of high quality and efficiency;

(x) its location as a unique research centre in the major rice producing region of the world, the excellent support and cooperation from its host country, in particular that of the Ministry of Agriculture and UPLB located in its immediate vicinity with the possibility of making field research and testing new field approaches on a pilot project basis in the Philippines;

(xi) the favourable environment for rice production in the Philippines makes it difficult for IRRI to address the problems of certain important types of rice production which are not present in the country. IRRI's good relationships with many other countries, however, make it possible for the Institute to develop cooperative arrangements for this purpose.

(c) The Changing Roles of IRRI in the Context of National Programme Development

IRRI's Mandate

531. The above assessment of IRRI's main achievements and of its comparative advantages does not imply that IRRI's functions should remain static. The Plan for IRRI's Third Decade proposes a number of changes but it is clear that several changes have already taken place in the basic objectives of the Institute and its strategies. These should be formally recognized and stated by updating the interpretation of its mandate. The Panel recommends that the interpretation of the mandate of IRRI should be updated to reflect: (i) its dual role in basic and applied research; (ii) its supportive role and servicing functions in the development of national rice research programmes and in the promotion of their cooperation; (iii) its involvement in rice-based cropping system research with a further broadening of its approach by contributing relevant rice technological components to farming system research development; (iv) its responsibilities in the maintenance and use of the world rice germplasm bank; and (v) the recognition of its responsibilities towards geographical regions outside Asia. Changes in the interpretation of IRRI's mandate also require further attention in particular as regards some post-harvest problems at farm and village level.

Future Strategies

532. The Panel strongly supports IRRI's proposal as regards its relationships to national and other international research efforts as outlined in its long term plan. The Panel recommends that the concepts presented by IRRI for its cooperation with other countries and institutions should constitute the backbone of its overall strategy in the implementation
of its mandate, namely: (i) the development of formal relationships and joint research planning; (ii) collaborative research; (iii) research networks; (iv) the provision of specialized supporting services to national rice programmes; (v) the training of rice researchers; (vi) the promotion of closer links between rice research, extension and production programmes at national level; and (vii) the promotion of communication activities, conferences and workshops among rice research scientists.

533. While agreeing with this strategy, the Panel strongly recommends that IRRI continue to decentralize at country level selected elements of its research and training activities in order to make fuller use of growing national capabilities. The Panel also recommends that IRRI increase its efforts in promoting cooperation among national rice research programmes.

534. The Panel also wishes to stress that the maintenance of an adequate level of basic research at IRRI is essential to the success of this strategy and to further technological advances in rice production and research cooperation. The Panel recommends that in implementing these strategies, IRRI should assemble and utilize more information on the environmental and socio-economic conditions under which rice is grown in different countries so as to better define common problems, set priorities and develop a more integrated approach in the characterization of the main rice environments and target areas for research and technology transfer.

535. The Panel recognizes that the development of rice production cannot be isolated at farm and village levels from other aspects of agriculture and therefore encourages IRRI in continuing research on rice-based cropping systems in cooperation with other countries. The Panel recommends that IRRI facilitate the collaboration of relevant institutions (national and international) in helping national programmes to tackle farming system research in a more integrated manner in the rice-producing regions.

Programme Priorities

536. Priorities of IRRI can be examined in several ways by functional area (such as research, training, etc.), by geographical areas and types of rice cultures, and by specific programme areas.

537. Priorities among the main functional tasks. The Panel agrees with the relative importance given by IRRI to its different main tasks of research, training, and dissemination of information. The Panel's recommendations in this respect refer more to the mode of implementation of the different functions following the strategy outlined above, namely some degree of decentralization of IRRI's
activities in research and training. This will probably increase operating costs. At the same time the Panel recommends that, resources permitting, a relative increase in emphasis be given to training and to selected aspects of dissemination of information in its core programme. The overall balance of activities of IRRI may, however, not be significantly affected if in the meantime IRRI continues to enlist the cooperation of scientists in advanced research in the several areas recommended by the Panel through special projects and other cooperative arrangements.

538. Priorities among different types of rice cultures and geographical areas. The Panel generally supports the priorities proposed by IRRI by which it will give increased attention to different types of non-irrigated rices, while maintaining a sufficient level of research for the fuller adoption and improvement of technologies in irrigated areas. The Panel is convinced, however, that further progress on different categories of non-irrigated rices will necessitate that some additional staff be recruited to concentrate on specific types of rice culture. The rationale in the Panel's recommendations takes into account the potential production increases from research as analyzed by IRRI for these different categories. It also takes into consideration the present stage of development of technologies and IRRI's input on different areas and types of rice, as well as the need to make special efforts for those marginal areas and social groups which have so far received little benefits from research and development efforts. Specific recommendations on upland rice are made by the Panel in Chapter IV. In a similar way, the Panel wishes to recommend that IRRI develop clearly identifiable and focussed programmes for each of the main categories of rice cultures. This will necessitate some changes in breeding procedures and some additional staff in breeding.

539. Balance among problem areas, programmes and disciplines. The Panel did not find a major imbalance in the present pattern of resource allocation to the problem areas, programmes and disciplines but recommends certain staff additions and shifts which will be required in the gradual implementation of IRRI's strategy in the third decade. These changes should take place using the existing procedures involving the staff, the Directorate and the Board as well as IRRI's collaborators in the review and formulation of the programme procedures, which the Panel strongly supports. The changes should lead to an increase in the relative importance of breeding and some supportive basic research.

540. The Panel recommends that IRRI examine the possibility of ensuring a similar integration of the disciplines as in GEU for such areas as environment analysis and assessment, soil-crop-water management and cropping systems within the limits of the presently available core resources for these activities and the assistance of non-core staff (visiting scientists, postdoctoral fellows, etc.). In doing so, the Institute should appoint programme leaders with clear responsibilities within the programme areas.
541. **Recommendations relating to resources requirements.** The Panel made a number of recommendations in the relevant chapters dealing with IRRI's programme. Among these, the Panel wishes to present here those which may have a bearing on the future resource requirements and allocations to the Institute. These recommendations are:

(i) The Department of Plant Breeding needs strengthening in view of the strategies and priorities indicated for GEU in Chapter III and in IRRI's plan for its third decade. Resources should be found to create the appropriate number of breeder-positions which would enable IRRI to give separate attention to five major categories of rice culture, to hybrid rice and to other innovative breeding techniques and related physiological aspects.

(ii) The established positions for the head of the Plant Pathology Department and a senior plant pathologist should be filled as soon as possible.

(iii) The INSFFER coordinator should be part of the core staff.

(iv) The position of soil physicist recommended by the first Quinquennial Review should be established and filled.

(v) The editorial staffing of the Information Services Department should be reassessed in order to enhance their training capacity and delivery in the context of the strategy of IRRI for its third decade.

(vi) Additional support staff and other means should be provided to the germplasm bank to fulfill its growing obligations.

(vii) An electron microscope and a suitable computer facility should be made available to IRRI as soon as possible.

(viii) Additional screenhouse facilities as recommended by the first Quinquennial Review should be provided so as to alleviate the pressure on the phytotron.

(ix) The Board and the Directorate should pursue their efforts in streamlining the procedures for administration and accounting, and for the efficient use and maintenance of IRRI's resources and facilities.

(x) Consideration should be given to the possibilities of retaining off-campus staff during interim periods between their fixed term contracts, by a revolving fund or other appropriate means.
The Panel realizes that the above recommendations call for a major increase in IRRI's resources. The Panel also notes that IRRI has been successful so far in attracting special project support, contracts, visiting scientists and postdoctoral fellows to fill some of its requirements. The Panel however wishes to stress that some of the above requirements are of a more continuing nature than others, especially those referred to under (i), (ii), (iii) and (iv) in order of priority and should therefore be part of the core programme of IRRI.

Several programmes are relatively well staffed. Some of these should be considered for a relatively larger proportion of special project support to alleviate pressure on the core budget that will result from the above recommendations. The quality of and the interest shown in IRRI's activities in machinery development and some aspects of its economic work and irrigation water management could attract special project support.

Final remarks. The Panel noted with some concern that IRRI is experiencing a stringency in available funds because of the policy of no growth for "developed" Centres. IRRI is an outstanding research institution with a proven record of accomplishments and its results have had a significant impact on rice production, particularly in Asia. Just the impact of IR36 alone would more than justify the investment in IRRI since its establishment 21 years ago. Other major achievements are forthcoming and the above recommendations are essential for their realization.

IRRI's basic strengths could be further weakened if it is asked to take on other responsibilities without additional support and at the expense of existing programmes. The Panel would not favour such an approach, and would suggest that the donors and scientific research institutions consider special support to IRRI as recognition of its strong staff and programme, and the impact of its work.
The Quinquennial Review Panel wishes to thank IRRI's Directorate for the comprehensive preparations made for the Review, for the efficient organization of the Review timetable and for the hospitality which the Panel enjoyed during its stay at IRRI.

The Panel gratefully acknowledges the assistance and hospitality of the IRRI staff, the Indonesian Government Officials, and the Philippines Government Officials during field visits.

The Panel is also grateful to the Chairman and Members of IRRI's Board of Trustees for having shared the final stage of the Review, and to IRRI's Directorate and scientific staff with which the Panel had numerous informative and interesting discussions.

Finally, the Panel is particularly grateful for the diligence of the secretarial staff, namely: Leticia R. Quintos, Victoria M. Sebastian, Carlos Domingo, Edeliza Yalong, Araceli Carretas, and Rolando R. Quintos, who painstakingly assisted in the preparation of the several drafts and without whom the draft report would not have been finished in time to provide copies to the Board of Trustees and the Directorate at the conclusions of the Review.
Policies, Strategies and Management

1. What was the impact of the recommendations of the first Quinquennial Review?

2. Are the strategies, conclusions and recommendations of IRRI's Long Range Planning Committee Report sound, relevant and useful in the determination of research priorities, and what reactions have there been from developing countries? What are their implications in terms of future staff and other requirements? What are the views of the management regarding IRRI's long-term plans and their implications?

3. Is the relative importance given by IRRI to the different types of rice cultivation - i.e. irrigated, upland, lowland, deepwater - in accordance with recent developments in Asia and other regions of the world? What problems are associated with high input rice culture? Is there scope for a better identification of research needs and concentration of research means on specific types of rice cultivation and/or rice growing environments?

4. What is the nature and magnitude of basic research which is and should be carried out by IRRI? Does IRRI make the fullest possible use of back-up and more basic research carried out in developed country institutions? What is the nature and magnitude of such collaborative research, and what are the funding arrangements?

5. In view of the increasing strength of the breeding activities in the national programmes, is there now in the revised programme structure of IRRI an adequate balance between the different aspects of basic and mission oriented research on rice, in particular as regards plant breeding and other activities, such as soil-water-crop management and socio-economics?

6. Are IRRI's programmes adequately flexible to provide an effective input to national and regional programmes, to meet their changing requirements, and to accommodate the need to address specific problems of soils, moisture stress, different types of rice cultivation and cropping systems? To what extent does this call for a further decentralization of IRRI's programmes to off-campus sites more representative of the problems to be studied? How can flexibility be maintained in designing strategies and responses to problems which change in nature from place to place and with time? Should the use of resources, now allocated to "permanent" staff, be considered for additional short term consultancies for such specific purposes?

1/ This list of questions should be seen as a supplement to the Terms of Reference and does not pretend to fully cover all IRRI activities, nor all the questions to be raised by the Review Panel in addressing the Terms of Reference.
7. Are IRRI's research programmes adequately linked - through national extension services - with the needs and constraints as experienced under farmers' conditions, to ensure sufficient feedback? What effort is made to monitor the effectiveness of technology transfer?

8. Has the programme structure of IRRI evolved with its changing priorities? What are the most appropriate structures to link the activities in physiology, agronomy, pathology, entomology, socio-economics and cropping systems? Is there a need to reorganize the programme structure, in particular the GEU programme components? Is the management structure appropriate to IRRI's size and anticipated roles?

9. Do restricted core funds influence IRRI's research programme in a manner different from what it would be if all core funding were unrestricted? How is the balance of IRRI's core programmes influenced by extra-core activities (special projects)?

10. What are the requirements for maintenance and replacement of existing equipment, building and other facilities of IRRI after more than 20 years of activity? What are the needs for capital investment, if any, in conjunction with programme changes? What plans are being made for these?

International Networks, Cooperation with other IARCs and National Programmes

11. How effective is the dialogue and influence of rice growing developing countries on the programme development of IRRI and on its institutional linkages with national agricultural research systems? Are the cooperating national programmes satisfied with IRRI's response to their identified requirements? What are their most urgent requirements? What are the major constraints to more productive interaction and a more efficient division of responsibility between IRRI and the national programmes and how can these be alleviated? Would it be desirable to let some of the stronger national programmes take the lead and the coordinative role in what are now some of the IRRI's core activities?

12. What is and should be IRRI's involvement in rice research in Africa and Latin America vis-à-vis the rice programme in IITA, WARDA and CIAT? What are the specific relationships and working arrangements of IRRI with IITA, WARDA and CIAT at their respective headquarters and in their off-campus activities? What interactions exist or are planned between IRRI and ISNAR, IBPGR and IFPRI?

13. What is the optimum number, size and arrangement of the international nurseries and cooperation networks which IRRI can efficiently promote and operate? What are the best means for consultations among cooperators? Is the IRTP of manageable size?

Genetic Resources Evaluation and Utilization

14. How will the emerging techniques for regeneration affect IRRI's breeding methods and strategies?

15. Durable resistance to pathogens and pests would be desirable in rice

1/ For example, could IRRI and the Bangladesh Rice Research Institute (BRRI) intensify joint research efforts on improving rice growing technology for improved broadcast varieties and deepwater varieties, suitable for Bangladesh conditions?
varieties. Is this an objective of IRRI's breeding programme and how is the programme organized to attain it?

16. What are the applicability and prospects of the use of hybrid rice in developing countries of Asia and other regions?

17. What is the role of IRRI's research on rice quality in relation to consumer needs and preferences (taste, aroma, milling and cooking qualities, nutritional quality) in the various rice consuming areas of the world?

Pests and Diseases

18. What is the place of integrated pest and disease management in IRRI's programmes? What are the prospects of developing integrated control in practice in the various rice growing areas?

19. Rice insect pests and diseases are primary constraints to increased rice production, they are sometimes intensified by the very technologies required for high rice yields and intensified cropping systems. Recent outbreaks of rice diseases and pests emphasize the potential catastrophies which could occur if these pests and diseases are not properly managed; which role should IRRI play through its own research efforts and through cooperation with scientists in both developing and developed countries to properly manage these pests and diseases, e.g. ICIPE?

20. In view of the substantial losses attributed to rodents and birds, what role should IRRI play in developing strategies to manage these pests? What consideration does IRRI give to post harvest crop losses?

Less Favourable Rice Growing Conditions

21. Do IRRI research programmes give adequate consideration to the medium to marginal rice growing conditions, as they do to the good to medium conditions?

22. What is the optimum balance and focus of IRRI's activities in research on drought tolerance and other aspects of upland rice research?

23. Should IRRI give greater attention to characterizing the various rain-fed environments in which most of the world's rice is produced?

Soil-Water-Crop Management, Plant Nutrition and Cropping Systems

24. Has an adequate delineation of responsibilities and adequate priority of research in soil, water and crop management research, and in cropping systems research been established? Do the International Networks related to these activities provide adequate opportunity to take into account location-specific aspects in agronomic studies?

25. To what extent does IRRI's current work focus on fertilizer efficiency, including reducing leaching losses? Are the efforts put into work on fertilizers and those on biological nitrogen fixation adequately balanced? Is current research on biological nitrogen fixation by free-living bacteria, blue-green algae and azolla/blue-green algae associations, and the necessity to maximize the enhancement of nitrogen fixation in rice paddy soils adequately geared to the needs of the small farmer, who cannot afford expensive nitrogen
fertilizer?

26. What advances have been made by IRRI to develop appropriate technology for direct seeding of rice for small farmers in the region?

27. Can IRRI carry out adequate research on cropping systems which involve crops other than rice, while having itself limited research activities and expertise in these other crops in the light of the work conducted by other IARCs and the national programmes?

Socio-Economic Aspects

28. What changes have taken place and are anticipated in the objectives of the socio-economic research programmes of the Centre? How does this programme integrate with and influence other research programmes of IRRI and other institutions concerned, in and outside the CGIAR system?

29. Is the balance of research efforts on technology development, and assessment of the social and economic implications of the effect of those technologies appropriate?

Farm Machinery

30. What is presently IRRI's main emphasis in its rice mechanization programme? What should be the role of IRRI in the promotion and development of farm mechanization under the socio-economic circumstances of the farmer, and in determining its impact on production, employment and related socio-economic aspects?

31. What is the respective involvement of IRRI's staff, other IARCs (e.g. ICRISAT, IITA), national programmes and private industry in the work on farm machinery? Is IRRI's involvement in the appropriate form and receiving correct priority?

Training and Support Services

32. Are the programmes and facilities for training at IRRI appropriate and adequate for the present needs of the collaborating countries? Should greater emphasis be given to in-country training? How can the needs of African and Latin American countries be best accommodated?

33. Are the various service facilities, particularly in documentation and computing, adequate for the requirements of an institute of IRRI's current size?
ANNEX II

COMPOSITION OF THE REVIEW PANEL

Panel Chairman:

Dr. A. Blumenschein 1/
Director, CNPAF
National Centre for Research on
Rice and Beans
Caixa Postal 179
Goiania - GO. - 74000 (Brazil)

Panel Members:

Dr. Kenzo Hemmi
College of Agriculture
University of Tokyo
Bunkyu-ku
Tokyo (Japan)

Mr. P.J. Mahler (in personal capacity)
Executive Secretary, TAC
Food and Agriculture Organization
of the United Nations
Via delle Terme di Caracalla
00100 Rome (Italy)

Dr. Yoshio Murata
827 Shimohideya
Okegawa City
Saitama-Pref., 363 (Japan)

Dr. I.N. Oka
Director of Food Crop Protection
Directorat Perlindungan
Tanaman Pangan, Pasar Minggu
Jakarta, Selatan (Indonesia)

Panel Secretary:

Mr. L.H.J. Ochtman
Senior Agricultural Officer, TAC
Food and Agriculture Organization of
the United Nations
Via delle Terme di Caracalla
00100 Rome (Italy)

Dr. W.H. Patrick, Jr.
Laboratory for Wetland Soils and
Sediments
Louisiana State University
Baton Rouge, Louisiana 70808 (USA)

Dr. Sukhdev Singh
Vice Chancellor
Punjab Agriculture University
Ludhiana (India)

Dr. Harry Will
P.O. Box 52
Moyamba
(Sierra Leone)

Dr. J.C. Zadoks
Professor of Plant Pathology
Department of Phytopathology
Agricultural University Wageningen
Binnehaven 9
6709 PD Wageningen (The Netherlands)

Ex Officio:

Dr. D. Plucknett
Scientific Advisor
CGIAR Secretariat
1818 H Street, N.W.
Washington, D.C. 20433 (USA)

1/ As the Panel Chairman designate resigned at a late stage from participating in the Review due to circumstances beyond his control, the Chairman of TAC requested Dr. A. Blumenschein to assume the leadership of the Panel, and Mr. P.J. Mahler, Executive Secretary of TAC, to attend the Review in a personal capacity and to provide assistance to the Panel Chairman. Mr. Mahler joined the Panel on its arrival in Los Baños.
ANNEX III

PROGRAMME AND ITINERARY OF THE REVIEW PANEL

Sunday, 3 January 1982

p.m. Review Panel assembled at Jakarta
20.00 - 21.00 Panel meeting for briefing

Monday, 4 January 1982

07.00 Departure Jakarta by bus
10.30 Arrival Sukamandi (West Java) at Research Institute for Food Crops (SURIF).
10.45 - 11.30 Review Panel meeting
11.45 - 17.00 Discussions with:
- Dr. I. Manwan, Director of the Centre for Agricultural Research Programming
- Dr. B.H. Siwi, Director of SURIF
- Dr. Suryatna Effendi, Director of the Bogor Research Institute of Food Crops (BORIF)
- Dr. I.N. Oka, Director of Food Crop Protection.

19.30 Visit of the station's laboratories and experimental fields
21.00 - 22.00 Dinner with Dr. B.H. Siwi, Director of SURIF

Tuesday, 5 January 1982

08.00 Departure Sukamandi by bus
08.30 Arrival Jatisari - Field Laboratory of Plant Protection

09.45 Departure Jatisari

10.30 Arrival Talagasari - Field Extension Office

12.00 Departure Talagasari
16.00
Arrival Jakarta

19.00
Dinner with H.E. Ir. A. Affandi, Junior Minister of Food Crops Production, Ministry of Agriculture, Jakarta
- Prof. Dr. Ir. I.G.B. Teken, Professional staff to the Junior Minister of Food Production
- Prof. Dr. Ir. Achmad Satari, Professional staff to the Junior Minister of Food Production
- Ir. Suhaedi, Professional staff to the Junior Minister of Food Crop Production

Wednesday, 6 January 1982

07.30
Departure Jakarta by air

08.00
Arrival Telukbetung (South Sumatra)

08.30
Departure Telukbetung by bus

10.45
Arrival Way Abung area

Cooperation of Cropping Systems Group in the Central Research Institute for Food Crops (Bogor) and I.P.B. (Agricultural University Bogor) with Directorate General of Transmigration

Discussions with Messrs. Subowo (Team leader), Toto, Adesuherma and Imo of the Cropping Systems Group, and with Messrs. Frans Daiwin (Team leader Agricultural Mechanization) and Iskandar, at Pulung Kancana, Daya Murni and Mulyakencana). At Nambahjadi discussions with Ir. Made Saba and Ir. Imtias Basah

19.00
Arrival and night at Tanjungkarang

Thursday, 7 January 1982

07.00
Departure Tanjungkarang by bus

08.00
Departure Telukbetung by air

08.30
Arrival Jakarta

10.00 - 11.00
Industrial Extension Project, Jakarta
Discussions with Mr. V.R. Reddy, Agricultural Engineering consultant of IRRI

13.00 - 14.30
Half of Review Panel had discussions with Ir. Subandi, Directorate General of Water Resources Development, Jakarta.

14.00 - 15.00
Other half of Review Panel had discussions with H.E. Prof. Ir. Soedarsono Hadisaputro, Minister of Agriculture, Jakarta

15.15 - 16.45
Review Panel meeting

19.00 - 21.00
Dinner with Dr. J.R. Cowan, IRRI Liaison Scientist in Indonesia and Malaysia
Friday, 8 January 1982

08.45 - 15.30  Review Panel discussions with:

(i) IRRI resident staff in Indonesia:
- J.R. Cowan, Liaison Scientist
- Dr. H.M. Beachell, Plant Breeder
- Dr. J.L. McIntosh, Cropping Systems Agronomist
- Dr. J.R. Hooper, Cropping Systems Agronomist (Sulawesi)
- Dr. V.R. Reddy, Agricultural Engineer

(ii) USAID resident staff in Indonesia:
- Dr. W. Tappan, Chief Office of Agricultural Development
- Dr. B. Primm, Project Officer/Agricultural Economist
- Dr. A. Hurdus, Agronomy Advisor (Research)

(iii) World Bank resident staff in Indonesia:
- Mr. M.J. Walden, Chief Agricultural Division

(iv) FAO/UNDP staff in Indonesia:
- Mr. W.T. Khan, FAO Programme Officer
- Mr. E. Abeyaratne, FAO Senior Advisor, Project INS/78/007
  Improvement of Rainfed Farming Systems, Palembang, South Sumatra

18.00 - 20.00  Dinner with Mr. Sadikin, Head of Agency for Agricultural Research and Development (AARD), Bogor

Saturday, 9 January 1982

08.00  Departure Jakarta by air
15.30  Arrival Manila
18.00  Arrival IRRI, Los Baños by car

Sunday, 10 January 1982

09.30 - 12.30  Review Panel meeting
14.30 - 17.30  Review Panel meeting

Monday, 11 January 1982

08.30 - 12.00  General overview of IRRI's research and training programmes, organization and management, by:
- Dr. M.R. Vega, Acting Director-General and Deputy Director General (International Programmes)
- Dr. D.J. Greenland, Deputy Director-General (Research Programmes)
- Dr. M.D. Pathak, Director Research and Training Coordination
- Mr. H.T. Murphy, Director Administration

13.00 - 17.00
Presentations and discussions on:
- Research Programme Overview, by Dr. R.W. Herdt
- Strategies for Rice Production Increase
  (i) Increasing production per crop, by:
    Dr. T.T. Chang, Geneticist, Plant Breeding Dept.
    Dr. S. Yoshida, Plant Physiologist, Plant Physiology Department
    Dr. M.D. Pathak, Director, Research and Training Coordination
    Dr. G.S. Khush, Plant Breeder, Plant Breeding Dept.
  (ii) Increasing the cropping intensity by:
    Dr. J.W. Pendleton, Agronomist, Multiple Cropping Systems
    Dr. G.L. Denning, Visiting Field Specialist, Research Production & Research
    Dr. I.D. Haws, Crop Production Specialist

17.00 - 18.15
Review Panel meeting
18.30
Reception by Dr. M.R. Vega, Acting Director-General

Tuesday, 12 January 1982
09.00 - 17.00
Presentations and discussions continued on increasing production per crop, by:
- Dr. D.J. Greenland, Deputy Director-General (Research Programmes)
- Dr. D.V. Seshu, Plant Breeder, International Rice Testing Programme
- Dr. F.N. Ponnamperuma, Principal Soil Chemist, Soil Chemistry Department
- Dr. S.K. De Datta, Agronomist, Agronomy Dept.
- Dr. I. Watanabe, Soil Microbiologist, Soil Microbiology Department
- Dr. S.I. Bhuiyan, Associate Ag. Engineer, Irrigation Water Management

(ii) Increasing the cropping intensity by:
- Dr. J.W. Pendleton, Agronomist, Multiple Cropping Systems
- Dr. G.L. Denning, Visiting Field Specialist, Research Production & Research
- Dr. I.D. Haws, Crop Production Specialist

17.30 - 1900
Review Panel meeting
Wednesday, 13 January 1982

08.00 - 12.00  Presentations and discussions continued on increasing the cropping intensity, by:
    Dr. C.W. Bockhop, Agricultural Engineer, Agricultural Engineering Department
    Dr. J.C. Flinn, Agricultural Economist, Agricultural Economics Department
    Dr. R.W. Herdt, Agricultural Economist, Agricultural Economics Department

13.00 - 17.00  Review Panel divided into three groups, i.e. A, B, and C for in-depth discussions of IRRI's programmes
    Group A: GEU Programme discussed with:
        Dr. M.D. Pathak, Director, Research and Training Coordination
        Dr. T.T. Chang, Geneticist, Plant Breeding Dept.
        Dr. S.K. De Datta, Agronomist, Agronomy Dept.
        Dr. B.O. Juliano, Chemist, Chemistry Dept.
        Dr. D. Hillerislambers, Plant Breeder, Plant Breeding Department
    Group B: Discussions on Irrigation Water Management with:
        Dr. S.I. Bhuiyan, Associate Agricultural Engineer
        Dr. A.C. Early, Associate Agricultural Engineer
        Dr. R.W. Herdt, Agricultural Economist, Agric. Economics Dept. and on Machinery Development and Testing with:
        Dr. C.W. Bockhop, Agricultural Engineer
        Dr. M.L. Nafziger, Agricultural Engineer
        Dr. B.J. Cochran, Visiting Agricultural Engineer
    Group C: Discussions on International Programmes and Regional Liaison, with:
        Dr. M.R. Vega, Acting Director-General
        Dr. J.R. Cowan, Liaison Scientist for Indonesia and Malaysia
        Dr. L.D. Haws, Crop Production Specialist, Philippines
        Dr. F.W. Sheppard, Research Systems Specialist and IRRI representative in Bangladesh
        Dr. J.S. Townsend, Agricultural Engineer and IRRI Team leader in Burma
        Dr. Kaung Zan, Liaison Scientist for Africa

17.45 - 20.00  Review Panel meeting
Thursday, 14 January 1982

08.00 - 17.00 Review Panel Groups A, B and C in-depth discussions of IRRI Programmes

Group A: CECU Programme discussions continued with:

Dr. E.A. Heinrichs, Entomologist, Entomology Dept.
Dr. R.C. Saxena, Associate Entomologist
(IRRI/ICTP Project)
Dr. G.S. Khush, Plant Breeder, Plant Breeding Dept.
Dr. K.C. Ling, Plant Pathologist, Plant Pathology Dept.
Dr. S.K. De Datta, Agronomist, Agronomy Dept.
Dr. T.T. Chang, Geneticist, Plant Breeding Dept.
Dr. S. Yoshida, Plant Physiologist, Plant Physiology Department
Dr. F. Ponnampuruma, Principal Soil Chemist, Soil Chemistry Department
Dr. C.S. Chung, Visiting Scientist, Plant Breeding Dept.
Dr. S.S. Virmani, Plant Breeder, Plant Breeding Dept.
Dr. F.J. Zapata, Associate Plant Physiologist, Plant Physiology Dept.
Dr. D.V. Seshu, Plant Breeder, International Rice Testing Programme
Dr. T.R. Hargrove, Editor and Head, Office of Information Services

Group B: Discussions on Soil and Crop Management with:

Dr. F.N. Ponnampuruma, Principal Soil Chemist, Soil Chemistry Dept.
Dr. D.P. Garrett, Research Associate, Agronomy Dept.
Dr. J.R.P. Fillery, Associate Soil Scientist (IRRI/IFDC Project)
Dr. S.K. De Datta, Agronomist, Agronomy Dept.
Dr. I. Watanabe, Soil Microbiologist, Soil Microbiology Dept.
Dr. P.A. Roger, Visiting Scientist (ORSTOM)
Dr. L.D. Haws, Crop Production Specialist, Philippines
Dr. C.P. Mamaril, Agronomist (INSFFER)
Coordinator

Group C: Discussions on Consequences of New Technology and Mechanization, and Training Programmes, with:
Dr. R.W. Herdt, Agricultural Economist, Agricultural Economics Dept.
Dr. M. Kikuchi, Associate Agricultural Economist, Agricultural Economics Dept.
Dr. J.A. Wicks, Associate Agricultural Economist, Agricultural Engineering Dept.
Dr. L.A. Gonzales, Associate Agricultural Economist (IRRI/IFPRI Project)
Dr. M.D. Pathak, Director, Research and Training Coordination
Dr. H.H. Hagerman, Visiting Communications Specialist, Rice Production Training and Research (RPTR)
Dr. L.D. Haws, Crop Production Specialist, Philippines
Dr. S.S.Virmani, Plant Breeder, Plant Breeding Dept.
Dr. J.R. Cowan, Liaison Scientist for Indonesia and Malaysia
Dr. J.S. Townsend, Agricultural Engineer and IRRI Team leader, Burma
Dr. F.W. Sheppard, Research Systems Specialist and IRRI representative, Bangladesh

17.45 - 20.00
Review Panel meeting

Friday, 15 January 1982

08.00 - 17.00
Review Panel Groups A, B and C in-depth discussions of IRRI Programmes:

Group A: Discussions continued on GEU Programme, and on Control and Management of Rice Pests, with:
Dr. G.S. Khush, Plant Breeder, Plant Breeding Dept.
Dr. T.T. Chang, Geneticist, Plant Breeding Dept.
Dr. D. Hillerislambers, Plant Breeder, Plant Breeding Dept.
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Dr. E.A. Heinrichs, Entomologist, Entomology Dept.

Dr. J. Perfect, Associate Entomologist (IRRI/ICIPE Project), Entomology Dept.

Dr. R.C. Saxena, Associate Entomologist (IRRI/ICIPE Project), Entomology Dept.

Dr. V.A. Dyck, Entomologist, Entomology Dept.

Dr. K.C. Ling, Plant Pathologist, Plant Pathology Dept.

Dr. D.B. Lapis, Senior Research Fellow, Plant Pathology Dept.

Dr. K. Moody, Agronomist, Agronomy Dept.

Group B: Discussions on Cropping Systems Programme, with:

Dr. J. Pendleton, Agronomist, Multiple Cropping Systems Dept.

Dr. J.A. Litsinger, Entomologist, Entomology Dept.

Dr. K. Moody, Agronomist, Agronomy Dept.

Dr. S. Jayasuriya, Associate Agricultural Economist, Agricultural Economics Dept.

Mr. G.L. Denning, Visiting Field Specialist

Dr. R. Lantican, Director, Institute of Plant Breeding, UPLB

Dr. G.S. Khush, Plant Breeder, Plant Breeding Dept.

Dr. V.R. Carangal, Agronomist, Multiple Cropping Systems Dept.

Dr. R.A. Morris, Agronomist, Multiple Cropping Systems Dept.

Dr. L.D. Haws, Crop Production Specialist, Philippines

Dr. R.I. Cochran, Visiting Agricultural Engineer, Agricultural Engineering Dept.

Dr. M. Zahidul Hoque, Senior Research Fellow, Multiple Cropping Systems Dept./BRRI, Bangladesh

Dr. Ed. Quisumbing, Director, Agricultural Research Office, Ministry of Agriculture, Philippines
Group C: Discussions on Information Services, Library, Administration, Service Units and on Constraints on Rice Yields, with:

Dr. T.R. Hargrove, Editor and Head, Office of Information Services
Mr. H.T. Murphy, Director, Administration
Dr. J.C. Flinn, Agricultural Economist, Agricultural Economics Dept.
Dr. R.W. Herdt, Agricultural Economist, Agricultural Economics Dept.
Dr. S.K. De Datta, Agronomist, Agronomy Dept.
Dr. S.I. Bhuiyan, Associate Agricultural Engineer, Irrigation and Water Management Dept.

17.45 - 20.30

Review Panel meeting

Saturday, 16 January 1982

08.00 - 09.45

Review Panel discussed Upland Rice with:

- Dr. M.R. Vega, Acting Director-General and Deputy Director-General (International Programmes)
- Dr. D.J. Greenland, Deputy Director-General (Research Programmes)
- Dr. M.D. Pathak, Director, Research and Training Coordination
- Mr. H.T. Murphy, Director, Administration
- Dr. T.T. Chang, Geneticist
- Dr. S.K. De Datta, Agronomist
- Dr. J.C. Flinn, Agricultural Economist
- Dr. E.A. Heinrichs, Entomologist
- Dr. R.W. Herdt, Agricultural Economist
- Dr. G.S. Khusk, Plant Breeder
- Dr. K.C. Ling, Plant Pathologist
- Dr. K. Moody, Agronomist
- Dr. J.W. Pendleton, Agronomist
- Dr. F.N. Ponnamperuma, Principal Soil Chemist
- Dr. D.V. Seshu, Plant Breeder
- Dr. S. Yoshida, Plant Physiologist
- Dr. D.P. Garrity, Research Associate
10.00 - 12.00  Review Panel discussed requests for additional staff and new facilities with:
- Dr. M.R. Vega, Acting Director-General and Deputy Director-General (International Programmes)
- Dr. D.J. Greenland, Deputy Director-General (Research Programmes)
- Dr. M.D. Pathak, Director, Research and Training Coordination
- Mr. H.T. Murphy, Director, Administration
- Mr. F.M. Salacup, Controller

p.m.  Quinquennial Review Report preparation

Sunday, 17 January 1982

04.30 - 22.00  Three Review Panel members visited cropping systems and machinery manufacture at Iloilo, accompanied by:
- Dr. L.D. Haws, Crop Production Specialist
- Dr. D.J. Greenland, Deputy Director-General (Research Programmes)
- Dr. J.R. Cowan, Liaison Scientist for Indonesia and Malaysia
- Dr. F.W. Sheppard, Research Systems Specialist and IRRI Representative, Bangladesh
- Dr. V.R. Carangal, Agronomist
- Dr. R.E. Stickney, Agricultural Engineer

08.00 - 17.30  Five Review Panel members visited irrigation water management, fertilizer efficiency and constraints to higher rice yield studies in Central Luzon, accompanied by:
- Dr. M.R. Vega, Acting Director-General and Deputy Director-General (International Programmes)
- Dr. M.D. Pathak, Director, Research and Training Coordination
- Dr. G.S. Khush, Plant Breeder
- Dr. S.K. De Datta, Agronomist
- Dr. E.A. Heinrichs, Entomologist
- Dr. S.I. Bhuiyan, Associate Agricultural Engineer
- Mr. F.M. Salacup, Controller

(i)  At Santa Barbara, Llanera, Nueva Ecija the Panel had discussions with:
- Mr. V. Santos, Chief of Research and Development Dept. NIA
- Mr. Rodrigo Bautista, Project Director, NIA

(ii) At Maligaya Rice Research Centre, the Panel had discussions with:
- Mr. T. Eugenio, Director of MRRTC, and his staff

(iii) At Bayambang, Pangasinan, the Panel had discussions with members of the IRRI Cropping Systems Team, i.e.:
- Dr. J.C. Flinn, Agricultural Economist
- Dr. G.L. Denning, Visiting Field Specialist
- Dr. S.V.R. Shetty, Postdoctoral Fellow
- Mr. Romeo Zarraga, Provincial Agriculture Executive Officer, Ministry of Agriculture
- Mr. Datum, Barrio Head
- Mr. Bravo, Agriculture Technician

Monday, 18 January 1982

a.m. Review Report preparation
13.30 - 14.15 Review Panel meeting
p.m. Review Report preparation

Tuesday, 19 January 1982

a.m. Review Report preparation
13.30 - 22.45 Panel reviews report drafts

Wednesday, 20 January 1982

a.m. Review Report preparation
11.00 - 12.00 Panel reviews report drafts
13.00 - 15.30 Review Panel visit of IRRI field experiments and laboratories
15.45 - 20.00 Panel reviews report drafts
20.45 - 00.15 Panel reviews report drafts

Thursday, 21 January 1982

a.m. Review Report preparation
11.00 - 12.30 Panel reviews report drafts
14.00 - 16.30 Panel reviews report drafts
17.00 - 18.30 Panel meeting with members of the Board of Trustees:
Dr. Gurnett-Smith (Programme Committee Chairman)
Dr. A.M. Islam, Dr. In Hwan Kim
Friday, 22 January 1982

07.30 - 13.00  Panel reviews report drafts
14.00 - 14.45  Review Report preparation
15.00 - 17.00  Panel meeting with:

Dr. Clarence Gray, Chairman, Board of Trustees
Dr. Gurnett-Smith, Programme Committee Chairman
of the Board of Trustees
Dr. A.M. Islam, Member, Board of Trustees
Dr. In Hwan Kim, Member, Board of Trustees

20.30 - 23.00  Panel reviews report drafts

Saturday, 23 January 1982

08.30 - 10.30  Review Panel Chairman presents Panel's conclusions
and recommendations to the representatives of IRRI's
Board of Trustees, IRRI's Directors and Senior staff,
and brief discussion.

P.M.  Departure Review Panel
Visit of Dr. H. Will, Quinquennial Review
Panel Member, to WARDA and IITA

15 November 1981
Freetown, Sierra Leone to Monrovia, Liberia

16 - 17 November 1981
At WARDA for discussions with:
- Mr. S. Cooper, Farm Superintendent Nursery Farm, Suakoko
- Mr. K. Conteh, Head of Training Centre
- Mr. D.K. Awuteh, Director of Training
- Mr. D. Sanni, Deputy Director, Development Department
- Mr. B. Guindo, Head of Documentation
- Dr. A.O. Abifarin, IITA Liaison Scientist
- Dr. B.A.C. Enyi, Director of Research
- Dr. Nat Bangurah, Associate Pathologist
- Dr. M.A. Choudhuri, Senior Breeder
- Dr. D.K. Das Gumpta, Senior Agronomist

18 November 1981
Monrovia, Liberia, to Ibadan, Nigeria

19 - 21 November 1981
At IITA for discussions with:
- Dr. B.N. Okigbo, Deputy Director-General
- Dr. Yamaguchi, Rice Physiologist
- Dr. M.S. Alam, Rice Entomologist
- Dr. S.V.S. Shastry, Director of Research
- Dr. K. Aluri, Rice Agronomist/Breeder
- Dr. E. Hartmans, Director-General
- Dr. Y. Efron, Leader Cereal Improvement Programme
- Dr. E.R. Terry, Assistant Director-General International Programmes
- Dr. Kaung Zan, IRRI Liaison Scientist

22 November 1981
Return to Freetown, Sierra Leone
ANNEX IV

BRIEFING DOCUMENTS FOR REVIEW PANEL

A. Documents provided by TAC Secretariat

Terms of Reference and Guidelines
List of Questions
Report of IRRI's first Quinquennial Review
Report of ICRISAT's Quinquennial Review
Extract from 23rd TAC Report on Upland Rice
Progress Report on Upland Rice for 26th TAC Meeting
Extract from 26th TAC Report on Upland Rice
Extracts of TAC Meetings Reports related to IRRI

Report on Farming Systems Research at the International Agricultural Research Centres (September 1978)

CGIAR Brochure

Tentative Programme for Panel

Proposed Outline IRRI Quinquennial Review Report
IRRI Off-Campus Activities (August 1980)

In Addition, the Review Panel's Economist was provided with:

Extracts from Agriculture: Toward 2000 (FAO, 1979)
Interdepartmental Task Force on Rice Production in South and Southeast Asia Report, (FAO, 1978)
Regional and National Development Strategies - Some Selected Issues for the 1980s, (FAO CR1/22)
Resource Potential and Investment (IRC/76/8) - International Rice Commission - 14th Session
Regional Overview of Development (IRC/77/4) - International Rice Commission - 14th Session
Report of the 14th Session of the International Rice Commission, Rome 1977
Long-Term Strategy of Rice Development (IRC/82/3) - International Rice Commission - 15th Session
B. Documents provided by IRRI

The Articles of Incorporation and By-Laws

A Plan for IRRI's Third Decade - A Proposal for Discussion with the Quinquennial Review Team

A Volume entitled "Summary of Organization and Plans for Future Activities" containing:

(i) IRRI's Mandate and Programme Committee Comments
(ii) Structure and Organization of IRRI
(iii) Recommendations of the 1975 Quinquennial Review Team and IRRI's responses
(iv) Summary of Objectives, Accomplishments, and Work Plans (1982-87) of the Research Programmes
(v) Summary of Work Plans by Rice Cultural Type
(vi) Outline of Cooperation and Collaboration with National Research Programmes
(vii) Summary of Training Activities and Plans
(viii) Notes on Information Dissemination, Library Activities and Workshops, Conferences and Symposia

Proposed Programme and Budget, 1982-83
Annual Reports for 1976 - 1979
Research Highlights for 1976 - 1980
List of IRRI's Publications
Indonesia-IRRI Working Relationship
Off-Campus Activities - IRRI - 1981

C. Documents provided during Review Panel's Visit to Indonesia

Five Years of Agricultural Research and Development for Indonesia (1976-80), published by the Ministry of Agriculture, Agency for Agricultural Research and Development (Badan Penelitian dan Pengembangan Pertanian) Jalan Ragunan 29 Pasar Minggu, Jakarta Selatan, Indonesia

Indonesian Farming Systems Research and Development (Draft - 191), by Jerry L. McIntosh and Surjatna Effendi


The GEU Concept in Indonesia by B.H. Siwi and H.M. Beachell

Problems of Implementation of Insect Pest Management for Rural Communities in Indonesia, by Sadji Partoatmodjo, Head of Pest and Disease Control Division, Directorate of Food Crop Protection, Pasar Minggu, Jakarta, Indonesia
INTERNATIONAL COOPERATION

Cooperative Projects with National Programmes

Bangladesh - IRRI supports the development of the Bangladesh Rice Research Institute (BRRI). A team of four IRRI scientists are stationed there consisting of a research system specialist functioning also as IRRI representative, a rice production specialist, a rice breeder (deep-water rice) and an entomologist. In addition, IRRI is to strengthen the rice-based cropping systems research capability of the BRRI. For this purpose one scientist is assigned to the project.

Burma - The purpose is to strengthen the national rice research capability. It aims at developing and implementing strong interdisciplinary programmes in rice varietal improvement, rice-based cropping systems and machinery development.

Egypt - IRRI's support focuses on programmes in mechanization and applied research trials.

Indonesia - IRRI's involvement is to strengthen the national rice research capability. A team of five scientists are assigned for this purpose, i.e. a rice breeder, a cropping systems specialist, an agronomist, a soil scientist, and an agricultural economist. Their activities include genetic evaluation of rice, research on cropping systems, and agro-economic constraints to rice yield. A project has also been included to provide assistance to increase the use and the effectiveness of mechanization in rice production. The activities concern redesigning or modifying the machines to suit specific local conditions, demonstrations, and inviting manufacturers to produce IRRI designed machines.

Pakistan - IRRI's main involvement in Pakistan is in the area of small scale farm machinery and applied research trials. IRRI is conducting economic and market evaluation studies for the IRRI-designed machines. Threshers and transplanters are receiving major attention. The applied research trials are aimed at demonstrating the potentials for increased rice production at farmers' fields. These include nitrogen placement, direct seeding, zinc deficiency, insecticides and double cropping.

Sri Lanka - The objective of the cooperation has been to strengthen organized multidisciplinary research on varietal improvement and cropping systems.

Philippines - The primary objective is focussed on assisting in the transfer of technology. An IRRI crop production specialist is working with the Masagana 99 in cooperation with the agricultural extension.
Thailand - IRRI's assistance to Thai manufacturers in the evaluation, modification and manufacture of IRRI-designed machines.

Collaborative Research Projects with National Programmes

Indonesia - Cropping systems on rainfed or partially irrigated rice areas, including training of researchers and extension workers.

India - Collection, exchange and evaluation of germplasm, biotype and strain studies, crop production research and exchange of scientists.

Philippines - IRRI is requested to provide technological support through research in the resettlement areas in the province of Agusan del Sur. Investigation of nutritional and acceptability problems related to rice-based diets in preschool children in cooperation with the Philippine Food and Nutritional Research Institute. Cooperative effort of Philippine Council for Agriculture and Resources Research, NFAC, NIA, DPI, BAE and IRRI to organize small farmers for effective use of technology to increase yields.

Korea/Philippines - Screening for cold tolerance and blast disease resistance. Gene rotation with production of rice seeds in the Philippines during the Korean winter to shorten the rice seed renewal period by three to five years.

Indonesia/Philippines/Thailand - Studies on the consequences of mechanization. The project will evaluate the effects of farm mechanization on small rice farms in selected locations in Asia. Improvement of the national research capability to conduct soil studies.

Cuba/Vietnam - To provide scientists of these countries opportunities to participate in IRRI's conferences and training programmes, and to consider possible collaboration on special projects.

China/IRRI - Collaboration in training programmes concerning both degree, non-degree and short courses, particularly GEU and INSFFER. The Chinese Academy of Agricultural Sciences and IRRI co-sponsored short courses on hybrid rice and tissue culture, followed by a workshop in tissue culture attended by scientists from developed and developing countries in China.

IRRI helped to develop a plan for the Chinese National Rice Research Institute. Chinese scientists are also participating in GEU, IRTP and INSFFER network monitoring tours. A Chinese specialist, who developed hybrid rice in China, spent a year at IRRI. An engineer spent six months at IRRI to adapt the Chinese reaper to the Philippine condition. Two postdoctoral fellows were at IRRI for research in a particular field.
PRESENT AND PROJECTED RESEARCH STAFF DISTRIBUTION BY RESEARCH AREA
AND RICE CULTURAL TYPE

Most staff contribute to more than one research area, and more than one rice cultural type. Assignments are based on the staff members assessment of the division of their time between different activities.

a) By Research Programme Areas

<table>
<thead>
<tr>
<th>Research Programme Areas</th>
<th>1978 - 1980 Scientist Years</th>
<th>1984 - 1985 Scientist Years</th>
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<td></td>
<td>Core</td>
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<td>Genetic Evaluation and Utilization</td>
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<td>Soil and Crop Management</td>
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<td>Control and Management of Pests</td>
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<td>Irrigation Water Management</td>
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<td>Constraints to Rice Production</td>
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<td>Consequences of New Technology</td>
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b) By Type of Rice Culture

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1/ The data referred to is included for information only and does not in any way reflect the views of the Review Panel. Extract from "A Plan for IRRI's Third Decade; A Proposal for Discussion with the Quinquennial Review Team", IRRI, January 1982, Table 1.2, p. 14.
## Summary of Man-Years by Organizational Units (1979-1985)

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* Does not include IFPRI staff member working at IRRI.
** Does not include IFDC staff member working at IRRI.
*** Does not include ICIPE staff member working at IRRI.
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**GLOSSARY OF ACRONYMS**

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<th>Acronym</th>
<th>Full Form</th>
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<tr>
<td>AARD</td>
<td>Agency for Agricultural Research and Development (Indonesia)</td>
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<td>ACSN</td>
<td>Asian Cropping Systems Network</td>
</tr>
<tr>
<td>ADAB</td>
<td>Australian Development Assistance Bureau</td>
</tr>
<tr>
<td>CIAT</td>
<td>Centro Internacional de Agricultura Tropical (Colombia)</td>
</tr>
<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organization</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization</td>
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<tr>
<td>GEU</td>
<td>Genetic Evaluation and Utilization</td>
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<td>ICIPE</td>
<td>International Centre for Insect Physiology and Ecology (Kenya)</td>
</tr>
<tr>
<td>IDRC</td>
<td>International Development Research Centre (Canada)</td>
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<tr>
<td>IFDC</td>
<td>International Fertilizer Development Centre (USA)</td>
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<tr>
<td>IFPRI</td>
<td>International Food Policy Research Institute (USA)</td>
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<tr>
<td>IITA</td>
<td>International Institute of Tropical Agriculture (Nigeria)</td>
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<tr>
<td>INSFFER</td>
<td>International Network on Soil Fertility and Fertilizer Evaluation for Rice</td>
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<tr>
<td>IPB</td>
<td>Institute of Plant Breeding (Philippines)</td>
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<tr>
<td>IRAT</td>
<td>Institut de Recherche Agronomique Tropicales et des Cultures Vivrières (France)</td>
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<td>IRTP</td>
<td>International Rice Testing Programme</td>
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<tr>
<td>KABSAKA</td>
<td>&quot;Kabusugan sa Kaumahan&quot;, an Ilongo (Philippines) phrase meaning bounty on the farm</td>
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<tr>
<td>LTCC</td>
<td>Laboratory, Training and Conference Centre</td>
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<td>Masagana 99 or M-99</td>
<td>The Philippines Rice Production Programme; Masagana means &quot;bountiful&quot;</td>
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<td>ORSTOM</td>
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<td>RPA</td>
<td>Research problem or programme area</td>
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<tr>
<td>TAC</td>
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<td>UPLB</td>
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<td>WARDIA</td>
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<td>World Meteorological Organization (Switzerland)</td>
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