Report of
the Third External Review of
the Asian Vegetable Research
and Development Center

April 23 - May 14, 1984

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Dr. Paul C. Ma
Chairman, Board of Directors
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Shanhua, Tainan 741, Taiwan
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Dear Dr. Ma:

It gives me great pleasure to pass to you the report of the AVRDC External Review Panel. With your acceptance of the report, and after the discussion of its contents at the 17th meeting of the Board of Directors on May 14, the Review Panel's job will be completed.

It is our earnest hope that we as members of the Review Panel have provided the kind of objective overview of AVRDC's programs, activities, administration, and management which the Board of Directors expected when it requested the review.

The review itself has been a challenge to the Panel. It has been hard work, but exceedingly interesting. The task would have been much harder without the willing cooperation of the Center's staff and management.

As you will appreciate upon reading the report, we are very positive about the Center and its programs, particularly its potential for making major contributions in the years to come with its present and future mandate crops.

We wish AVRDC well, and hope that the report will have a beneficial effect on its future development.

Yours sincerely,

Guy Vlaeyens
Chairman

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FOREWORD

The Review Panel assembled at AVRDC during the weekend of April 21-22, 1984 and began its activities the following Monday morning, continuing throughout that week. On Sunday, April 29, the Panel members divided themselves into three teams to visit and review AVRDC's outreach activities in Thailand, the Philippines, and Taiwan. The panel re-assembled at AVRDC on the evening of Thursday, May 3. After reporting briefly to AVRDC's senior management on the three outreach reviews, the team continued its discussions with staff and its examination of AVRDC's programs and practices, and began preparing this review document on the weekend of May 5-6 (see Appendix 1).

The Panel reported its findings to the AVRDC staff and to several members of the Board of Directors at a meeting on Saturday, May 12, after which some members of the Panel left AVRDC because of prior commitments.

The remaining members, including the Chairman and the Secretary, reported to the full membership of the AVRDC Board on Monday, May 14, and the duties of the team were considered to have been completed at that time. The remaining members of the panel left AVRDC on Tuesday, May 15.

The members of the Review Panel wish to express their appreciation for the frank and open manner with which the AVRDC staff and management participated in the review and the courtesy and friendliness with which the Panel was received. AVRDC's program of activities was thoroughly and completely displayed for the team's consideration, including constraints and impediments. In particular, the team wishes to express its appreciation for the courtesies that the three outreach review teams had extended to them during their short but interesting studies of the AVRDC outreach programs in Thailand, the Philippines, and Taiwan. The frankness and openness of those involved, both at AVRDC headquarters and in the cooperating countries, made the team's difficult task much more pleasant and less onerous than it would otherwise have been.

The team also wishes to express its warmest appreciation for the social invitations that it received. They provided an opportunity to learn something about what being a member of the AVRDC family involves, and the team is most grateful.

The following report is presented for the use of the AVRDC Board, donors, and interested friends. The review team hopes that the report will be useful, that it will contribute to AVRDC's future growth and development, and that it will help to increase the Center's impact on vegetable production and on the health and welfare of the citizens of the tropics and subtropics.

The Panel has been very impressed by the productivity and efficiency of the research operations conducted by the Center, in spite of
the financial constraints that the Center has lived with almost since its establishment. We trust that this report will confirm the value of the support extended by the Center's present donors, and that both the numbers of donors and the Center's financial resources will increase in the near future to permit even more significant research and training contributions.

The team members take full responsibility for any errors and misconceptions that the report may contain. For whatever helpful suggestions the report may include, the complete and helpful discussions held with the AVRDC staff and management must be given due credit.

On behalf of the Review Panel

Guy Vallaeyts
Chairman
EXECUTIVE SUMMARY

This summary is arranged so that each of its numbered sections correspond to the report's Table of Contents.

1. **Introduction**

The Third External Review of the AVRDC took place from April 23 to May 12, 1984. The eight Panel members presented a formal report to the AVRDC Board of Directors on May 14, 1984.

2. **Nature and Structure of AVRDC**

The review dealt with the nature and structure of AVRDC (mandate, organization, and management), its crop research programs, the disciplines and services supporting Center research, its training and cooperative programs, research management, and administration and financial management. The report also provides an overall assessment of the performance and potential of the Center, an analysis of its long-term plans, and the problems and possible solutions involved.

AVRDC's objectives can be summarized as research, training and relaying information to farmers through national research and extension services. It is noteworthy that neither the Center's Memorandum of Understanding nor the Charter defines the species to be included as vegetables, nor names the species on which the Center was expected to concentrate.

The so-called "mandate crops" of the Center, as formally designated by the Board, currently include two legume crops (soybean and mungbean) and three horticultural crops (Chinese cabbage, tomato and sweet potato). The Board can add to or modify the list as it sees fit.

There are no restrictions in the original Memorandum of Understanding or the Charter which would prevent the association of AVRDC in the system of International Agricultural Research Centers, assuming that the mandate is amended accordingly.

3. **Legume Program**

AVRDC has succeeded in tropicalizing soybean by reducing its sensitivity to short day length and high temperatures, and has incorporated resistance to a number of important pests and diseases. The Review Panel's comments are as follows.
3.1 Soybean

The Panel supports an expansion of the germplasm collection, which is already the largest tropical collection in the world. In the final stages of varietal evaluation, the testing of soybean materials under simulated conditions for intercropping and paddy cultivation should be strengthened.

"Selection indices" should be established for critical traits that make for broad adaptation and stability in yield, as well as tolerance to soil stresses in tropical and sub-tropical climates.

Joint planning workshops and international monitoring tours of screening trials should be established when funds allow.

The Panel supports the move that has been initiated to synthesize and distribute broad-based segregating populations to national breeding programs for selection purposes.

The Panel supports AVRDC's plan to conduct joint screening for resistance to rust, beanfly, and borer in selected Asian countries. The Panel further recommends that joint efforts be mounted to study and establish resistance against yellow mosaic virus disease, a pathogen which poses a threat to the developing soybean industries on the Indian Sub-continent.

The Panel recommends that efforts be strengthened to develop low and high input technologies as options for the varied clientele of the farming communities of Asia. Appropriate methodologies for testing integrated management practices are needed.

3.2 Mungbean

The Panel feels that the initial success of the Mungbean program is commendable. Yield potential has been increased to about 2.7 t/ha from 0.3 to 1 t/ha. Plant architecture has been changed, resistance to CLS and PM has been developed and incorporated into advanced lines, pod maturity has reached 80% at first harvest, and plants are less photosensitive than before.

The Panel urges that additional accessions be acquired from mainland China, Vietnam, Burma, and other countries.

It encourages AVRDC's program to supply a wide range of breeding lines to national programs at various stages of selection.
It feels that more yield potential estimates should be made under farmer's conditions to determine appropriate inputs.

The Panel suggests that a greater effort be made to realize the benefits that interspecific hybridization may offer. It also recommends that a distribution and damage survey of mungbean viral diseases be conducted in major growing areas.

The Panel has considered the proposal that the mungbean program be evaluated with respect to the question phasing it down in three to five years. The Panel agrees that the interspecific hybridization program should be continued until its potential is established, and that the international program needs to be expanded to transfer the new mungbean technology to client countries.

4. Horticultural Program

4.1 Chinese Cabbage

The Panel has been impressed with the effectiveness of the Chinese cabbage research in developing a number of F₁ hybrids and open pollinated lines widely adapted to production under high temperature conditions in the humid tropics. The rapid acceptance of AVRDC lines and their release in Taiwan, the Philippines, Korea, and Japan has confirmed the value of these materials.

The Panel recommends that the direction of the Chinese cabbage program be carefully evaluated in the next year to examine the possibility of reducing its activities to a level that would still ensure that the progress made over the past is maintained for the future. If and when the activities in the Chinese cabbage program are reduced, the Panel recommends that activities on another crop be considered for inclusion as a new mandate crop. Regardless of whether an active Chinese cabbage program exists at AVRDC, the germplasm collection should be maintained as an active working collection in which characterization and new accessioning are adequately supported.

Based on the suggestion to reduce inputs in the total program to a maintenance level, the Panel recommends that concentrated short-term efforts be made to produce more time-and space-efficient disease screens for later use in maintaining improved stocks already in the program.

Any reduction in the Chinese cabbage breeding program should not reduce AVRDC's responsibility to ensure seed
supply, and to support international testing, national coöperative programs, and training. In view of the possibility of de-emphasizing the improvement of Chinese cabbage, the Panel suggests that technical information bulletins be prepared on the attributes of the AVRDC lines, providing detailed information on recommended cultural practices and on seed production.

4.2 Tomato

The Tomato program has succeeded in "tropicalizing" the crop so that it sets fruit in the summer. AVRDC heat tolerant, bacterial wilt resistant lines have been released in more than 15 countries. Important progress has been made in identifying in the germplasm, and incorporating into the breeding program, characters for disease and insect resistance and for fruit quality.

While there are many tomato diseases, exact information on their occurrence and their relative importance in various locations in different seasons is still required. The Panel recommends that such a disease survey be conducted in the near future. Until the survey is completed, priorities for resistance breeding of less important diseases cannot be established.

Based on the progress made by the physiologist concerning the effect of high temperatures on fruit setting, the Panel recommends continuation of the study to improve the heat tolerance of existing cultivars.

As processing tomatoes are expected to become more important in the tropics, the Panel supports the continuation of the processing tomato program within the limits imposed by financial and staffing constraints. To accelerate the program, the Panel supports the proposal to obtain access to an experimental site in the highlands to permit experimentation during the hot, monsoon season. The site selected should be easily accessible.

4.3 Sweet Potato

The Sweet Potato program has made substantial progress in developing high yielding, nutritious selections adapted to the low input cropping systems of tropical Asia. Most AVRDC elite lines are orange-fleshed, rich in vitamin A, early maturing, and have the potential to produce yields ranging from 20 to 40 t/ha. AVRDC accessions have been released in the Philippines, and AVRDC-selected disease-resistant materials have found their way into other national programs.
The Panel recognizes that the major constraint in the introduction of improved AVRDC materials to national programs has been the difficulty of processing virus-free material for wide distribution. In view of the fact that sweet potato is largely vegetatively propagated, the application of meristem culture methods, coupled with careful virus indexing, has to be adopted before reliable disease-free distribution can be guaranteed. The Panel was informed that plans are being made to provide additional facilities and a quarantine glasshouse to facilitate the production and distribution of AVRDC selections to national programs. The Panel recommends that priority attention be given to the application of techniques for meristem culturing and virus indexing, and to the early movement of both cultivars and lines to variety improvement programs.

AVRDC has recognized the changing status and needs of Southeast Asian agriculture, and survey results indicate that sweet potato is likely to play four different roles in the future. The Center has therefore proposed in its five-year plan to devote attention to types that are suitable to food, dessert, feed, and industrial uses. It appears to the Panel that the demands of such a diverse program are excessive in relation to the resources available, both human and financial.

The Panel recommends that AVRDC Management should undertake a review of stated program objectives with a view to applying more vigorous priorities in determining what can be done with the present resources if additional resources are not made available. In any case, the Panel recommends that an overall review of sweet potato research be undertaken within the next four years to determine appropriate levels of research inputs for this crop. Such a review should take account of any changes in the status of the crop, and how successful AVRDC has been in overcoming the problem of distributing its improved materials.

In order to assist with the distribution problem, the Panel recommends that AVRDC collaborate with other international agencies and research centers such as the IBPGR, the South Pacific Commission, the Glasshouse Crops Research and Experimental Station (Holland), and the National Vegetables Research Station (UK) in establishing an internationally acceptable virus indexing system, and in training national program personnel in participating countries with a view to creating an international testing network for sweet potato.
5. Nutrition, Environment, and Management

5.1 General

The Nutrition, Environment and Management (NEM) program is aimed at gaining a better understanding of crop-environment interactions so that the potential of genetically improved varieties can be fully explored. The disciplines presently included in this program are: Chemistry, soil science, economics, food nutrition/anthropology, crop management, and soil microbiology.

The Panel recognizes that a high proportion of NEM staff time is, and should be, allocated to working directly with scientists in the commodity programs.

The Panel was favorably impressed with the contributions of the NEM staff. The title of the program adequately describes its activities, and there is good cooperation between its staff and the staff of other programs in solving specific problems.

However, the Panel agreed that the NEM program was being asked to cover too many activities over a wide range of specialities, which gave the impression that the program lacked cohesion and direction with respect to its general objectives and activities. The Panel recommends that AVRDC consider the establishment of a unit with the suggested title of "Central Resources and Services Unit" and that the existing program be re-named the "Production Systems Program".

The Central Resources and Services Unit would include Statistical and Computer Services, Chemical Analysis (including biochemical, soil, and pesticide analysis), and the Germplasm Resources Unit and Seed Laboratory.


The Panel felt that there was room for more cooperation between individual scientists working on related problems outside of the individual crop programs. The Panel suggests that the Production System Program be given clear objectives with respect to both its roles in commodity-specific research and in multi-crop, multi-disciplinary work associated with the development and testing of new AVRDC technology, both at AVRDC headquarters and in cooperation with national programs through the Center's outreach system. In this respect, the Panel recommends that on-station activities be
seen as a major responsibility of the Production System Program, and that off-station on-farm activities be carried out through the outreach programs, and usually in the first instance, through the Taiwan Cooperative Program. The word "development" would then be removed from the "Training and Development" part of AVRDC's organizational chart.

The research areas involved in the NEM program have had some of their contributions considered as part of the commodity programs. The remaining part of their activities are discussed under the NEM section, and are summarized below.

5.2 Soil Science

In analysing the functions of soil science to the AVRDC program, the Panel members noted that two kinds of contributions were being made, (a) the management of the soils of the Center's experimental plots, with their drainage difficulties etc. and (b) more general studies which are of basic interest to agriculture everywhere, and are not limited to the use of soils as media for vegetable production.

The Panel felt that there was a danger that in the future, soil science at AVRDC would steadily move toward basic soil science studies not directly aimed at solving vegetable production problems, which are all highly location specific. It is suggested that a study group composed of representatives of disciplines associated with soil science look at the appropriate role of soil science at AVRDC.

5.3 Crop Management

Crop Management concentrates on synthesizing a package of cultural practices for high-yielding varieties. Many of the individual management practices which make up a package of improved practices are location specific.

AVRDC has a problem in that while a package can be developed for the areas in Taiwan, to do so in other countries requires liaison with local specialists. The Panel considers that the initiation of an improved support program for crop management in the development of appropriate packages of cultural practices for outreach programs is a very important part of the technology transfer process, and should be accorded some priority when additional resources are available.
5.4 Agricultural Economics

The Agricultural Economics group has made a valuable contribution to the AVRDC program within the limits set by its budget. However, the Panel felt that there was scope for tightening its objective as regards the following points.

(a) Assisting scientists to foresee possible constraints to the adoption of AVRDC technology.

(b) Assisting scientists in understanding why technology was not adopted or only slowly adopted.

(c) Assisting national programs in improving rates of adoption.

(d) Assisting AVRDC research management in making overall assessments of the impact of AVRDC programs and evaluating alternative research strategies.

Considering the need for adequate leadership, the Panel recommends that high priority be given to making a senior appointment in the economic sub-disciplines most directly concerned with identifying and dealing with constraints to producer and consumer acceptance of new technologies and their products, namely production economics and marketing.

5.5 Chemistry/Nutrition

The Chemistry/Nutrition group has made considerable progress in identifying nutritionally beneficial vegetable traits for which screening is justified, and in the development of assay and screening methods.

A major interest in the chemistry group will continue to be human nutrition and the distribution of minerals, vitamins, amino-acids, and anti-metabolites in vegetable crops.

The Panel recommends careful consideration of the extent to which the group should be involved in the development of processing technologies within the context of AVRDC's mandate. Since a group from the University of Idaho will come to AVRDC to examine research areas concerned with post harvest technology for vegetables, discussions with that mission will be very helpful.
5.6 New Vegetables

One of the objectives of New Vegetables program is the evaluation of the yield and horticultural characteristics of commercially-available cultivars under tropical environments. This program is an appropriate activity for AVRDC, assuming that arrangements can be made for the establishment of the AVRDC Tropical Vegetable Evaluation Trials.

The Panel commends the results of the Center's study which has produced the proposal for the adaptability study for new crops, as a preliminary step before adding additional mandate crops to the Center's research activities. The Panel considers the candidate crops eminently suitable for future adoption as mandate crops.

The Panel is particularly sympathetic to the need for serious attention to the improvement of so-called "traditional" crops for which there is very little commercial interest or horticultural attention in national improvement programs, due, for example, to a crop's low productivity.

5.7 Nutrition Garden Program

The Panel was impressed with the concepts and achievements of the Nutrition Garden Program. The AVRDC staff involved in this project are obviously highly experienced and have thoroughly researched their proposals.

The Panel did not feel there was sufficient information available on which a decision could be based with respect to which garden types are most valuable, and recommends that the scientists in the garden project evaluate the relative benefits of each garden type with a view to concentrating research and development on one or two categories.

During the reviews of the outreach programs in Thailand and the Philippines, the Panel received favorable reactions to the performance and potential of the garden program. The Panel recommends that AVRDC continue the funding of the Garden Program, preferably from special project funds.

5.8 Soil Microbiology

Soil microbiology as a discipline has been added to the AVRDC core program through the recent appointment of a soil microbiologist seconded by INTSOY.

The research on tropical soybean-Rhizobium relations is a well conceived and well placed activity. It is entirely appropriate that AVRDC participate in such an activity.
Although AVRDC provides an attractive environment for soil microbiology research, the projects selected for research must be carefully chosen so as to complement the specific needs of the crop commodity programs.

The role of mycorrhizae and other "yield promoting rhizosphere micro-organisms" in promoting crop yields has yet to be substantiated. Before such expectations can be realized, significant "basic" research will be needed. The Panel questions whether such research should become an integral part of the core research program at AVRDC. However, the Panel recognizes that research on mycorrhizae could be carried on by visiting scientists or research students.

6. Disciplinary Research

With regard to Disciplinary Research, there are four disciplines involved in the genetic improvement of the Center's mandate crops, i.e. Breeding, Physiology, Pathology, and Entomology. The activities of these four disciplines have been summarized in the earlier commodity sections, which adequately covers the work of the breeders. The other disciplines are treated below from a more general point of view with respect to basic principles of their function, methodologies, laboratory resources, etc.

6.1 Physiology

The Physiology group conducts its research as a component of the Legume and Horticultural Crops Programs. The group consists of one Plant Physiologist and three Principal Research Assistants. While the physiologist participates in all research conducted by his group, each assistant is assigned to one or more specific crops. Since there are five mandate crops, the group is required to cooperate with these five crop committees, each having a few major research areas. Thus, the list of priority research subjects is bound to become excessive to a physiology group which has only one senior scientist.

There is serious danger under these circumstances that the quality of research may be eroded by this pressure, and the depth of the research may suffer. The group has been trying hard and has had some success in producing results.

Within the context mentioned above, the Panel encourages the physiology group to concentrate on fewer carefully selected priority research items. The Panel feels that the physiology
group should provide breeders with convenient and quick methods to screen germplasm and breeding lines for useful characteristics. Under the present situation at AVRDC, it would be difficult to achieve such a goal without adding at least a small number of junior members to the group.

6.2 Pathology

The Panel feels that considerable progress has been made in Plant Pathology toward the resolution of specific disease problems. Many sources of resistance have been identified and put into practical use by the commodity improvements programs, including resistance to powdery mildew and Cercospora leaf spot of mungbean, and bacterial wilt of tomato.

Pathology faces a large number of disease problems in five different crops. The Panel recognizes the need for additional manpower and recommends that the administration consider hiring an additional senior staff member and a number of junior researchers.

The Panel feels that it might be possible to concentrate on fewer important diseases. However, more attention should be paid to the virus diseases. The Panel recommends the provision of some greenhouse and controlled environmental facilities.

6.3 Entomology

Entomology as a discipline has made important contributions to the legumes and horticultural programs at AVRDC in the definition of pest problems, the identification of host plant resistance, and the investigation of some essential components for the development of implementable pest management programs.

The time is now ripe for the discipline to amplify its work by becoming more intensively involved in the design, development, evaluation, and implementation of pest management systems for the crops and the production systems associated with AVRDC's mandate.

The Panel recommends that as a matter of priority, a second entomologist be recruited in the area of integrated pest management.

The Panel recommends that when a second entomologist is appointed, a review of the entomological research work at
AVRDC be conducted with a view to establishing a careful balance between host plant resistance work and the development of pest management systems for the Center's legume and horticultural crops. The Panel considers that only limited work on insect rearing will be required and that controlled environmental rooms will not be required. It is recommended that a limited number of large incubators with temperature and humidity control be purchased.

7. Supporting Services

Under Supporting Resources and Services, the report deals with the Genetic Resources Unit, Statistical and Computing Services, the Office of Information Services, the Library and Documentation Center, and the Experimental Farm.

7.1 Genetic Resources

The Genetic Resources Unit represents a unique and invaluable regional and world resource of germplasm. The philosophical position taken by the GRU in maintaining a wide diversity of germplasm for each AVRDC crop as individually distinct accessions is entirely in keeping with its recognized position as a world germplasm resource.

The Panel supports the plans of the GRU to identify the collection gaps in each group, and on this basis obtain needed materials from other collections or by mounting collecting trips.

The Panel recommends support for the activities of the GRU, and that the leadership within the unit work actively to generate additional funds for special research activities from interested agencies.

A tissue culture facility has been planned for in the new seed laboratory and should be available late in 1984 or early in 1985.

Although there may be a need for tissue culture as a research tool in any number of the scientific disciplines supporting the various program areas at AVRDC, the development of further tissue culture facilities should be based on a demonstrated need developed through the normal channels of research management.

7.2 Statistical and Computing Services

With respect to Statistical and Computing Services, the
planning of the new computer system is an important accomplishment for AVRDC. The review team believes that the proposal has been thoroughly researched and supports its introduction.

Two-year appointments in statistical services are now funded directly by the Japanese government, with the second of these appointees taking up his position in May 1984. The Panel believes the position is extremely important to AVRDC and recommends that if Japanese support for the position is terminated at some time in the future efforts be made to fund the position from the core budget.

The Panel also recommends that the statistician should have greater involvement in experimental design than appears to have occurred in the past, and that he should assist researchers in performing their own analyses in order to maintain statistical standards.

7.3 Office of Information Services

The Office of Information Services has managed to produce large quantities of high quality work using small numbers of talented staff and minimal equipment. The review team is of the general view that it is time to increase the OIS staff complement and upgrade the unit's equipment.

The Panel endorses the Center's plan to acquire the services of a second editor. The Panel supports the publication strategies of OIS and the charging policy soon to be announced. The Panel endorses the plan to improve the Progress Report Summaries by adding a "Highlights" section. The Panel also suggests that some material from the Progress Report Summaries be incorporated into the Progress Report to avoid confusion and to make the Progress Report more useful as an annual report.

7.4 Library and Documentation Center

The Library and Documentation Center performs the function of a special agricultural library, but also serves as a documentation center on vegetable crops and as a selective disseminator of information services, providing access to computerized data bases.

Library activities are to be expanded in the form of a Tropical Vegetable Information Service (TVIS), partly funded by IDRC (Canada). Part of the grant is to be allocated to the purchase of a Hewlett Packard 3000 minicomputer to allow the use of the bibliographic package MINISIS. Acquisition of
the computer system will also allow computerization of other library activities, e.g. borrowing, bibliographies, serial listings, etc.

The AVRDC library compares favorably with other IARC libraries and the Panel supports the future developments foreseen.

8. Training

The review team was impressed with the importance attached to the Training Program at AVRDC and with the quality of the Center's programs, which compared more than favorably with those of other centers.

The training programs are well integrated with research. Both past and present trainees interviewed by the Panel commented favorably on the program. The Panel supports the proposal for the expansion of the present training facilities, while noting that the new capacity will meet only 40 percent of potential annual demand for training at AVRDC. The Panel recommends that the Board attach high priority to this project.

The Panel observed that there was room for expanding the training program in Thailand. The Panel recommends that AVRDC evaluate the potential for increasing the number of training programs conducted outside of Taiwan.

The availability of AVRDC staff and requirements for equipment and facilities might limit the number of courses in other countries, but they could have potential benefits in terms of reaching larger numbers of trainees at less cost and with greater relevance to local environmental conditions.

9. The Taiwan Development Program

The Panel recognizes that the Taiwan Development Program is somewhat distinct from other AVRDC outreach programs for a number of reasons. First, Taiwan is the Center's host, and as such the Center enjoys special relationships, including generous funding provisions not expected from other national governments. Secondly, Taiwan's horticultural industries are highly developed in economic and technological terms, compared with other client countries. Thirdly, it is natural to expect that, for reasons of convenience, a large proportion of the initial testing of AVRDC germplasm and technologies will be done in Taiwan. For similar reasons, the Taiwan Development Program has special importance to the AVRDC Training Program.
Despite these distinctions, the Panel recommends that the Taiwan Development Program be re-named the Taiwan Cooperative Program, largely to avoid confusion in terminology and in the use of the word "development". The Panel takes the view that all cooperative/collaborative/outreach programs should be associated with the further development and adoption of AVRDC technology in client countries.

The Panel observed that the objectives of this program are being clearly achieved through a wide range of largely informal but effective collaborative activities and relationships.

There is concern that quality improvement in vegetables, processing prospects, and export expansion may not be a priority area for AVRDC, given its commitment to improving the production and consumption of vegetables for improved food and nutrition among the poor peoples of tropical countries. The Panel feels that while AVRDC applied research in variety improvement, from the productivity, adaptability, and pest and disease resistance points of view, will continue to benefit many other countries, some attention to commodities such as processing tomatoes and other vegetable that generate cash income would be appropriate. The Panel recommends that AVRDC research and development continue to service the needs of vegetable farmers employing relatively highly developed technologies.

While recognizing the convenience of the Taiwan system for testing AVRDC germplasm and technology, it must be remembered that local economic and environmental conditions are distinctly different from those of most other client countries. The Panel recommends that AVRDC pay increased attention to the proper balance between the level of local testing versus the testing done in cooperation with other client countries. Further, while supporting research and development in high technology vegetable production, the Panel recommends that heavy emphasis be given to successfully disseminating AVRDC improved germplasm and technology to countries where basic nutritional and economic needs are not being met for low income farmers and urban people.

10. Outreach Programs

The Review Panel was made aware of the mature Outreach Program of Taiwan, Korea, and the Philippines which operate as full fledged partners with AVRDC. Field visits to the Taiwan Development Program, and to the Philippines and Thailand confirmed the value, efficiency and productivity of the operation. AVRDC's reputation is uniformly high in these countries, based on the appreciation of former trainees. Training is a major part of all such programs.
The feedback that AVRDC obtains from the reports on nursery trials and the identification of resistances to pests and diseases in material in such trials, is a very important part of the programs, and of the continuing partnership arrangements.

New national programs are being negotiated with Malaysia and Indonesia for the immediate future, and for the British West Indies and for Central America sometime later.

Observations and comments made by the Panel indicate the need for more support and visits from headquarters scientists when travel funds are available.

The establishment of AVRDC-organized international monitoring tours would be a valuable way to encourage regional scientific exchange and interactions, as would holding AVRDC workshops and seminars in various countries of the region in rotation.

The Review Panel suggests that of the various names applied to outreach programs, the practice at AVRDC should be to call them national cooperative programs, including the Taiwan program.

11. Research Organization and Management

Research Organization and Management are particularly important at AVRDC because of the limits on financial, physical, and personnel resources which must be divided among the five mandate crops. The management of these resources in the execution of research must be a matter of the highest priority. The Panel has thoroughly analyzed research organization and planning at AVRDC, and its comments are as follow.

Both the legume and the horticultural commodity groups have been able to focus their specific objectives; however, because of the limited number of senior specialists within each discipline, each scientist must select his/her particular inputs to a specific crop with great care so as not to dilute efforts to the point of being ineffective within the program. The Panel feels that judgments as to how best to partition one's time and research efforts are critical to the success of each group's objectives, and must lie with the commodity councils. The budgetary process, which establishes what share of a discipline's time and resources are devoted to any one crop, is obviously a potent tool for coordination.

The small number of senior staff at AVRDC, and the excellent living and working environment, has led to an intimacy and esprit de corps among the scientists that can be of great benefit to communications and at the same time be a deterrent to frank and candid evaluation of collegial research. Commodity team members, Crop Coordinators, Project Leaders, and the Director
General/Deputy Director General must be particularly sensitive to this issue in attempting to assist their colleagues in formulating research objectives and working plans, and in the allocation of budget resources so that they maintain the appropriate focus to the general and specific objectives of the crop or project.

The Panel found a diversity of activities within the Nutrition Environment and Management (NEM) Program that virtually precluded the development of a common set of objectives upon which research could be coordinated (already referred to in NEM section). As a consequence, the Panel recommends the restructuring of the organizational plan for research management by reorganizing the existing NEM program and creating a new "Central Resources and Services Unit."

Although it is implied in the title that the Central Resources and Services Unit would provide services and resources to other programs, it would be expected that the senior scientists in the unit would be actively engaged in research projects required for their particular disciplines, as well as directly collaborating in the research of other programs and disciplines.

Under the present conditions, with a limited number of senior scientists and research projects focused primarily through the Commodity Groups, the functioning of the Director General/Deputy Director General essentially as "directors of research" is appropriate and workable. If the numbers of research projects and senior scientists were to increase significantly, the roles of the Director General/Deputy Director General in research management would have to be carefully assessed with the objective of determining when a Director of Research, already suggested by senior management, should be added to the system.

12. Administrative and Financial Management

In order to evaluate the Administrative and Financial Management of AVRDC, the full Panel devoted two sessions to these matters. A consultation session with the regular staff was conducted by three of the members. In addition, the Chairman and Secretary met successively with the Director General and his immediate collaborators as a group and on an individual basis with their staffs.

The Panel gives full support to the actions which the Board has taken in order to discharge its responsibilities, and to the way that it achieves an understanding of the activities and problems of AVRDC.

Taking into account the possible evolution of AVRDC vis-a-vis the system of international agricultural research and the possible
association of the Center within the context of this system, the Panel considers it as being in AVRDC's interest to adopt and apply as closely as possible the Board procedures followed by other IARC's.

AVRDC has not limited membership on its Board to representatives named by participating governments, and by resolution has approved the addition of up to eight Board members named by the Board itself.

AVRDC's Board, according to the Board meeting minutes, serves the Center well, and is scientifically well qualified to make policy and program decisions. The Review Panel sees no need to suggest changes in the Board's membership. It does, however, feel that, in spite of the sterling service of the two Board Chairmen (and two Vice Chairmen) who have filled the position since AVRDC began, that there is a potential source of trouble in not having a limit on the number of times that the Chairman can be re-elected. The Review Panel recommends that the Board examine the merits of limiting the period of service of the Chairman to perhaps four or six years (i.e. re-elected once or twice). This recommendation should not be interpreted as putting any limitations on the term of service of the present Chairman, who continues to serve AVRDC well.

The Review Panel understands that the Executive Committee of the Board, which was recently constituted, does not normally have the authority to act on behalf of the Board between meetings. If called upon by the Director-General to deal with an emergency, it is limited to giving advice, making recommendations, and recommending full Board approval at the next meeting. The Review Panel suggests that an Executive Committee, composed of the Chairman, or in his absence, the Vice Chairman, the Director General and two other members of the Board, be given power to act on behalf of the Board whenever decisions must be taken prior to the next Board meeting, the quorum for the Executive Committee being three.

As to the Program Committee, the Panel suggests that Program Leaders and their staff report on past progress and proposed programs to the Committee immediately before (i.e. two days before) the annual Board meeting so that the Program Committee can report to the Board, and if necessary, have the benefit of the reaction of the Director-General and his staff.

The Review Panel suggests that the Board consider the advisability of establishing a two-man Finance and Audit Committee which would report to the Board on financial matters, including expected income and budget proposals. This committee would also report to the Board with respect to the external auditor's report after interviewing the auditor.
The Panel recognizes that the growth of research and outreach activities of AVRDC, which is expected to occur in the relatively near future, may justify a re-distribution of responsibilities by creating, as foreseen by the Directors General, the establishment of two directors in charge of research and outreach activities, respectively. The Panel does not, however, consider the appointment of the first of these positions as an urgent necessity under current conditions. As to the latter, new agreements likely to be concluded by AVRDC in various countries may justify its creation somewhat sooner.

A clear and complete analysis of personnel management at AVRDC has been presented to the Review Panel. The Panel has noted that a number of steps have been taken during recent years for improving the present management situation.

The Panel received indications from staff members - both senior and junior - that salary levels are not nowadays a major subject of complaint. All grades of staff are evaluated annually according to methods providing uniformity in the evaluation of personnel in various disciplines and responsibilities. Deficiencies in work performance are expected to be discussed with the staff concerned. While not totally exempt from criticisms expressed by some personnel (inevitable to some extent), the rating system utilized at AVRDC has been endorsed by the Review Team. The Panel encourages the management to maintain and increase the spirit of fairness and justice on which the system is based.

The Review Panel endorses the Center's policy of linking incentives to performance and encourages the maintenance of objectivity in the promotion procedures.

Turnover in professional personnel appears to be quite normal. Junior staff, on the contrary, has shown a relatively high rate of turnover, although significantly reduced as compared with what it was a few years ago. The Review Panel has noted that the Center's management has worked and continues to work on problems related to the regular staff situation, and has already improved the situation considerably. The Panel thinks that increased interaction should be arranged to enhance the feeling of satisfaction among the regular staff. Improvement in professional relationships between senior and junior staff within discipline areas and across programs should be considered in this respect. The Panel recommends that initiative be taken at the professional staff level in order to develop better intellectual involvement and participation with the regular staff in the planning and implementation of research work.

Although systematically organized at the Center, existing communication procedures may present some deficiencies which need to be identified. The Review Panel recommends that, in so far as
the regular staff is concerned, the existing communication mechanisms be reviewed and that a process be institutionalized for a regular dialogue between management and this group of staff members. A procedure should similarly be designed so that personnel at the lower levels have the privilege of dialogue on a regular and periodic basis with the supervisors and section heads in their work units concerning policies and activities in which they are involved.

The Panel thinks it necessary to encourage the adoption and implementation of measures that will allow post-doctorate appointments, preferably focused on specific core program interests, or aimed at filling recognized program deficiencies or areas of study that can be dealt with through relatively short appointments.

As already mentioned, the Review Panel suggests that, annually, at the occasion of one of their meetings, effective interaction could take place between the Board of Directors or its Executive Committee (or, when created, its Audit Committee) and the external auditor. The Board should also address itself to the question of a possible change or rotation of the firm engaged for the audit of AVRDC.

The size of AVRDC and the degree of complexity of the Center's operation do not justify the establishment of an independent internal control and audit department to perform the functions of an internal auditor.

AVRDC's administrative and financial structure appears to combine, with all necessary accountability, a relatively centralized operation and chain of command with a fairly simple financial system.

The Review Panel commends the Directors General and their collaborators for having managed to maintain a proper balance between supporting management and the main thrusts of the Center, in order to preserve the research functions of the crop programs.

13. Future Plans

With regard to future plans for the Center, the Review Panel has some comments, in general highly supportive, on the commodity programs and on the other major parts of the Center's program. The Panel does not consider that the very condensed discussion can be reduced further, and refers the reader to the complete text.

AVRDC proposes to select new vegetable crops for inclusion in its programs in the future, especially after the termination or re-
duction of the level of research on some of the current mandate crops. The Panel commends the preliminary study already undertaken at the Center to produce the proposal for the adaptability study for new crops. It urges that careful consideration be given to the criteria of contributions to food and nutrition in the final selection of new vegetables as mandate crops.

14. Other Strategic Considerations

14.1 Background

During the Panel's discussions, a number of Other Strategic Considerations were considered. Its conclusions are as follows.

14.2 Outreach Funding

On outreach funding, the Panel recommends to the Board that the Memoranda of Understanding for all future outreach programs financed by third party donors should include not only funds to cover all expenses, but, in addition, an allowance for overhead and headquarters services which is fixed at the same percentage as similar allowances agreed to by the CGIAR for outreach programs managed by other IARC's.

14.3 Seed Production Responsibilities

On Seed Production Responsibilities, the Panel feels that AVRDC has a duty to help client countries obtain seed for lines that AVRDC has produced, and which have been released as varieties, if the country does not have seed production capabilities. This duty may range from advice on where to train nationals in seed processing, to providing courses, to helping to locate seed distributors willing to produce and sell seed, and to arranging for seed producers to produce the seed on AVRDC's behalf.

The requirements for development and maintenance of seed production will vary considerably from crop to crop and nation to nation. It is essential that not only crop commodity groups but also the Director General/Deputy Director General give serious consideration to the policy implications of this critical issue.
14.4 Relationships With Other IARC's

On Relationships with Other IARC's, the Panel is satisfied that a healthy fraternal relationship exists, with a number of on-going examples (and others being discussed) of close collaborative arrangements operating well, with the approach being cooperation and sharing, rather than competition.

14.5 Varietal Adaptability and Relations With National Programs

On Varietal Adaptability and Relations with National Programs, the Panel notes that with the development of national competencies and significant crop improvement programs, AVRDC's research role may be best carried out by originating parental lines with specific characteristics and resistances, and reconstituted broad-based segregating populations that can be used by national programs to produce location specific varieties. National successes will provide a sense of accomplishment to both AVRDC scientists and their counterparts in national programs.

15. Overall Assessment

The Review Panel's Overall Assessment can be summarized as follows:

AVRDC is endowed with a staff of highly qualified, high quality senior and junior scientists together with senior managers that are both skillful and effective. The versatility of AVRDC's senior staff is matched only by the diligence and skills of the junior scientists and support personnel. Nowhere has the Panel seen such uniformly well-trained supporting scientists. Likewise, the supporting farm workforce of managers and field personnel has the dedication and skill levels that have ensured a high standard of operation.

The Panel is also aware that the present research management structure of formulating research proposals along crop and commodity lines, in which the scientific disciplines contribute their respective inputs into planning and execution, has been working well at the AVRDC. It also recognizes the need for close and continual monitoring of the system to ensure that an appropriate balance is maintained among the inputs of the individual disciplines to the overall program goals.

The Center enjoys the confidence of a number of national and international organizations who second personnel to members at AVRDC. This makes AVRDC's core budget go considerably
farther, and enables research to be conducted that otherwise could not be afforded.

During the past 10 years the AVRDC has made exceptional progress toward achieving many of the goals in its original mandate. Among its five mandate crops, Chinese cabbage has been successfully adapted to tropical cultivation; tomato has been significantly improved in its ability to grow and set fruit under high temperatures and high disease pressures; the architecture of the mungbean has been restructured and the genetic components of yield potential markedly increased; the soybean has been tropicalized to yield well under short day lengths in the presence of a number of biotic and abiotic stresses; and the sweet potato has been improved to produce high yields of nutritious roots for both food and animal feed.

Advanced lines of all crops are being effectively tested in national programs throughout Southeast Asia, and there is a strong and growing interest in the output of the AVRDC crops in many tropical countries in Oceania and the Western Hemisphere.

Management has provided a good balance in the distribution of personnel and funds to support research in the development of the five mandate crops.

The Panel is aware, however, that in the future the balance of support among the crops may have to be significantly shifted in the event that particular resources are needed in order to ensure that advanced materials reach the farmers of tropical regions for which they have been targeted.

As AVRDC reviews its accomplishment over the past ten years, we feel it has reason to be proud of its programs and research. As yet, there are only a few examples of substantial economic impact as the result of the Center's work, but these are significant where they exist. It is, of course, important to note that the effects of the research are just beginning to reach the national agricultural systems, and that in judging the quality and productivity of the programs, the potential for very significant improvements in vegetable production and supply in the tropics is obvious.

The influence of AVRDC's training program has already provided important improvements in strengthening the vegetable production resources of many nations by supplying well trained personnel. Clearly, the training component of AVRDC is one of its great strengths.

By status, scope, modalities of action, and tradition, AVRDC is an international center. Although its focus is regional, the impact of its research and development activities, the
dissemination of its results, and the development of its cooperative projects go beyond the geographical boundaries of tropical and subtropical Asia.

An excellent reputation and image has been built under the current name and we see no reason to suggest or encourage a change in the name of the Center.

The Panel has noted that the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) has over the years been giving consideration to the association of AVRDC with the system of IARCs in the context of possible new initiatives in international research on vegetables. The Panel encourages AVRDC to prepare itself flexibly for any joint efforts to strengthen vegetable research and development that may emanate from these considerations. The Panel is satisfied that AVRDC has proved its ability to organize and execute research on an international scale, and has credibility.

The Panel recommends finally that the future plans of AVRDC should place greater emphasis on the humid tropics, vegetable crops of the "traditional" type consumed by the poorer people, and on production systems. By doing so it will strengthen its strategy in contributing most effectively to food and nutrition in the tropics through vegetable research and development.
1. INTRODUCTION

Since its establishment in 1971, the Asian Vegetable Research and Development Center has had two external reviews and a number of internal reviews which concentrated primarily on the scientific qualities of the Center's research programs.

In 1982, the AVRDC Board of Directors requested the Director General to arrange for a full-fledged review in early 1984 by a panel of specialists not associated with AVRDC. Their objective would be to report on all aspects of the Center's operations, both at its headquarters and at its outreach programs.

In view of AVRDC's relationships with the other international agricultural research centers (IARC's), the scope and "Terms of Reference" (see Appendix 2) for the review were to be modeled on those established by the Consultative Group for International Agricultural Research (CGIAR) for the so-called quinquennial - now external - reviews of the IARC's. The members of the Review Panel were to be selected in a manner similar to those used for the quinquennial reviews.

The members of the Review Panel were recruited from a list which was originally compiled by the AVRDC Board of Directors and was later modified and amplified as a result of consultations between the Chairman of the Review Panel and the Director-General of AVRDC (see Appendix 3).

Periodic reviews of the work of individual international agricultural research centers are an accepted part of the overview responsibility that each center's board has on behalf of the center's donors.

Originally such reviews were held at irregular intervals, and might have involved only particular parts of a Center's program. In recent years, it has become a general practice to hold reviews every five years on all aspects of a Center's activities, including research activities, administration, and management. To obtain a truly objective examination of the center and its activities, the review panels are made up of specialists in the various disciplines with which the centers are concerned. The members are recruited from a number of countries on the basis of their international experience.

In addition to the Terms of Reference, a "Provisional List of Main Issues" was referred to the Review Panel for its consideration (see Appendix 4).

The documents made available to the panel described the nature and functions of AVRDC in detail, and proved to be excellent information on which to base the extensive discussions and
meetings held with AVRDC staff members. These materials were extensively used in the preparation of this report.

The Review Panel is required to make its report, both orally and in writing, to the AVRDC Board of Directors. The following document represents the written report. The report, having been commissioned by the Board, is the property of the Board, and may be used and distributed as the Board sees fit.

This review deals with the nature and structure of AVRDC (mandate, organization and management), its crop research programs, the disciplines and services supporting such research, its training operations, its cooperative programs with interested countries, the way research is managed, Center administration and financial management, an overall assessment of the performance and potential of the Center, an analysis of long-term plans, and the problems and possible solutions involved.

As indicated in the Table of Contents, the following sections provide the Panel's assessment of the Center with respect to each of its component programs.
2. NATURE AND STRUCTURE OF AVRDC

2.1 The chronicle of events that led to the establishment of AVRDC began with a suggestion in 1963 from USAID in Washington to its Southeast Asian missions that a research center devoted to improving the production of protein, vitamin, and mineral-rich vegetable foods be established in the region. The possible locations for such a center included Thailand, the Philippines, and Taiwan. With support from the Government of the Republic of China and its Joint Commission for Rural Reconstruction (JCRR), formal exploration of Taiwan as a possible location for the Center was undertaken, and the appropriateness of Taiwan was subsequently confirmed. This resulted in an agreement in 1968 by Japan, Korea, the Philippines, Thailand, the United States, the Republic of Vietnam, the Republic of China and the Asian Development Bank for a proposed five year budget of U.S. $7.5 million, with USAID and the ROC accounting for 70% of the total.

The Memorandum of Understanding for the establishment of AVRDC and the Charter of the Center were signed by the sponsors in May 1971. Before the end of the year, a site for the Center's headquarters and experimental fields, an area of 116 hectares near Shanhua, 19 km north of Tainan City, had been acquired by the ROC Government for the use of the Center. The first Director General was subsequently appointed, and contracts were signed for three of the Center's major buildings and staff housing. The first seminar presenting AVRDC experimental data was held in December, 1972.

2.2 The Mandate

The objectives of the Center, as stated formally in the Charter are exceedingly simple and straightforward, - i.e. "The Center shall pursue any and/or all of the following objectives pertaining to vegetable research and development:

(1) To conduct research on production and marketing programs and to assist participating countries in developing their own adaptive research programs.

(2) To carry out training in production and marketing programs, and to assist participating countries in developing more efficient training and marketing programs.

(3) To develop and provide basic information on improved production and marketing for use by extension services in participating countries."

These objectives can be summarized as research, training, and
relaying information to farmers through national research and extension services. It is noteworthy that neither the Memorandum of Understanding nor the Charter defines the species to be included as vegetables, nor names the species on which the Center was expected to concentrate.

As a result, the so-called mandate crops for the Center are those formally designated by the Board of Directors. The Board can add to or modify the list as it sees fit. While this arrangement may seem rather loose in comparison with the mandates of other Centers, it must be recognized that the charters of most other Centers include clauses such as "and such other matters as may be decided by the Board from time to time."

As a matter of practice, AVRDC's Director General and his senior staff are meticulous in the manner in which they make recommendations to the Board, so that the Board may consider, approve, modify as necessary, or reject, in order to maintain its legal responsibilities for controlling policy, program, and budget matters.

2.3 Strategy

The mandate crops originally included 12 crops (common cabbage, sweet corn, onion, egg-plant, pea, cowpea and water convolvulus as well as the Center's five present crops). The list of 12 was reduced to six in 1972, eliminating the crops mentioned above, and concentrating on two legume crops (mungbean and soybean) and four horticultural crops (tomato, sweet potato, Chinese cabbage and white potato). The white potato work was terminated in 1978, after successfully demonstrating that tubers could be produced under tropical conditions, partly because the International Potato Center (CIP) was extending its activities to Asia, and AVRDC did not wish to appear to be competing with CIP.

The present list of five mandate crops appears to be appropriate for the present. The crops were chosen on the basis of their ability to complement cereal diets in the tropics, particularly in Southeast Asia. In addition, consideration was given to crops with which AVRDC could potentially make a significant impact in a relatively short time. The present staff seems comfortable with the five crops, and there is no feeling that the number should be reduced. Similarly, there is a definite feeling among the staff that new crops cannot be added, under existing staffing constraints, unless work on one or more of the present crops is scaled down.

The Center's limited financial resources have forced some hard choices with respect to strategy - the heart of the Center's program is crop improvement, and this research (with related
activities) accounts for the largest part of the budget. Training is given high priority, but core funding is supplemented by non-core funding, either with bilateral funding from outside donors or funding by the trainees' employers.

The third objective is dealt with through cooperative programs with participating countries, by which the new technology is transferred first to national institutions concerned with crop improvement, and then, through training courses to both technical specialists and extension workers, and through the extension services to the farmers. All such cooperative programs are financed with funds from outside of the Center's core budget (also see Appendices 5 and 6).

By virtue of its location on the island of Taiwan, the Center has certain relationships with the Government of the Republic of China which it does not have with other national Governments. Taiwan being both AVRDC's host and its major contributor, a tight chain of links, informal to a large extent, have been established which have proven advantageous to both parties.

2.4 Overall Organization

Under the general policies established and the programs approved by the Board of Directors, the Center is administered by the Director General and his senior management team: the Deputy Director General (who like the Director General is qualified in agricultural research), the Director of Administration, and the Comptroller.

Research activities, with their associated services, are organized into three programs (see figure next page). These include the Legume Program (mungbean and soybeans); the Horticultural Program (tomato, sweet potato, and Chinese cabbage); and the Nutrition, Environment, and Management Program which includes some scientific disciplines and research areas participating in the crop programs. Each of these Programs is headed by a Program Leader, who, in the case of the Legume and Horticultural Programs, is also the crop coordinator for one of the mandate crops.

The crop programs are served most directly by the breeders, pathologists, entomologists, and physiologists who are part of a particular commodity group. Funds are allocated for each crop according to need, and are further apportioned among the disciplines serving that crop according to their requirements, as agreed to by the crop commodity group. Plant Pathology, for instance, has no budget of its own, but has five budget allocations, one from each of the crop committees with which the pathologists interact. The staff members of a particular discipline share offices and laboratories, but in view of their funds being controlled by the crop committees, and expenditures being subject
to approval by Program Leaders, it is obvious that research coordination is achieved on commodity lines rather than by discipline.

2.5 Management

The responsibility for program formulation and implementation rests with the Director General, acting within the policy directives and program decisions of the Board of Directors. All staff members are responsible directly or indirectly to the Director General, who in turn is responsible to the Board.

Research direction is a major part of the responsibility of the Director General and the Deputy Director General. Currently there is no position for a Director of Research. This role is filled by the Director General and Deputy Director General, both of whom sit on the crop commodity committees.

As indicated above, the crop committees are the most important part of research planning at AVRDC. Each committee plans its research strategy and priorities on the basis of the progress being made. Planning, however, cannot ignore the constraints imposed by limited funding, since budget requests greatly exceed expected income. Adjustments in research planning are made to fit the total resources available during a given calendar year. Such adjustments are first made at the crop committee level, followed by similar decisions at the program and Center levels.
3.LEGUME PROGRAM

3.1 Soybean

3.1.1 Historical Background

The soybean research program was initiated in 1973. Soybean was one of six crops chosen by virtue of its worldwide importance, nutritional significance as a protein source, and the paucity of knowledge and work relative to the Asian tropics.

Originally, AVRDC’s research thrust was confined to the Asian tropics and sub-tropics, but in the course of time, and as the work gained momentum, collaborative work expanded to other tropical and sub-tropical regions.

3.1.2 General Objectives

The breeding objectives of the soybean program are addressed to the commonly observed problems besetting production in tropical and sub-tropical regions. These include: 1) use of local or introduced cultivars which are low yielding and poorly adapted to unfavorable environments; 2) utilization of different cropping systems which require specific varieties; 3) the occurrence of endemic pests and diseases which are unique to the tropics; 4) use of minimal management inputs by farmers; 5) use of poor quality seed. The research thrusts of the Center are intended to address these production constraints.

3.1.3 Germplasm Collection

To date the Center has accumulated more than 10,500 accessions, mainly cultivated species (the collection also contains a number of wild species). These accessions were acquired directly from other germplasm repositories and from organized collection trips. The materials are presently undergoing systematic characterization and evaluation.

Germplasm collection constitutes the foundation of AVRDC’s breeding program. It has been used in identifying desirable genetic traits that are needed in varietal development. A number of these materials have become useful breeding stocks which have been shared with national programs.
The physical facility for germplasm storage in the Center is inadequate, but financial assistance has been obtained for the installation of a new facility for medium-term storage.

3.1.4 Breeding Programs

The soybean breeding program has a number of components which are intended to achieve specific objectives. Breeding work is a team effort among various disciplines.

Breeding for High Yield and Stability

The main objective of this project is to increase the yielding capacity of soybean in the tropics and to provide for greater stability over various growing seasons and cropping systems.

Two high yielding cultivars from Indonesia and Taiwan, (G2120 and G 2261 respectively), have been identified. These lines are bushy, multi-branched types that produce large number of pods per plant, characteristics that are the key to raising yield potential beyond 3 t/ha. Thus far, some 35 selections have been derived from G 2120 and G 2261.

Breeding for Wide Adaptability to Photoperiod and Temperature

Efforts were made to identify genotypes with low levels of sensitivity to photoperiod through differential plantings in October (short-day season) and March (long-day season). Lines that exhibited stability in flowering, plant height, and other yield-related characters were identified. One hundred lines were characterized as less sensitive to photoperiod and 75 as less sensitive to temperature. Four of these cultivars were used in the crossing program, and 55 selected lines have been generated.

Breeding for Resistance to Soybean Rust

Rust is a major disease problem in Asia. Germplasm screening at AVRDC showed that two accessions, G 8586 and G 8587, were rust resistant. These lines have been used in crosses, and 11 selected rust resistant lines have been developed. Six other accessions have been found to show resistance. A continuous search is necessary as resistance is overcome by pathogen mutation. Infective differences among regional strains of rust are known to occur.
Resistance to Other Diseases

The germplasm has been systematically screened at AVRDC for reaction to soybean mosaic virus. Accession G 38 and two derivatives, AGS 9 and AGS 129, have shown resistance. Many accessions have shown resistance to bacterial pustule downy mildew, purple seed stain, and root knot nematode. Resistance to these diseases is stable and can be readily fixed.

Resistance to Insect Pests

Four accessions of Glycine sojae (G 3089, G 3091, G 3122, and G 3104) were found to possess resistance to two species of beanfly (Melanagromyza phaseoli and Ophiomia centroceptus). The transfer of this resistance from G. sojae to G. max lines is now underway. Accession C 8755 appears to be resistant to stink bugs and other foliage feeders. The beanfly is a devastating pest in Thailand and Indonesia, and an occasional problem in the Philippines.

Resistance to Seed Deterioration

Loss of seed viability in the humid tropics often results in poor crop establishment. Seed viability is often associated with small seededness. Six AVRDC selections have been identified, through the assistance of IITA, using the "accelerated seed aging" technique. They are: AGS 129, C 3477, G 2106, G 8457, and two other breeding lines.

Flooding and Drought Tolerance

Soybean is sensitive to flooding and drought to varying degrees depending on location. Two AVRDC cultivars appear to tolerate soil flooding. Five lines have shown tolerance to mild drought. One line showed tolerance to both flooding and drought.

Development of Vegetable Type Soybean

One hundred-forty accessions were observed to be large seeded, a character required for vegetable-type soybeans. Two promising cultivars, G 9053 and G 9948, have been distributed for testing.

Breeding Overview

From 1973 to 1982, a total of 3,460 crosses have been made in an attempt to combine high yield, photoperiod
insensitivity, early maturity, good seed quality, and resistance to pests and diseases. Certain combinations of these characters have been combined in advanced lines which are channeled for location specific evaluation at the Center's outreach sites and cooperating stations in Korea, Thailand, Philippines, Indonesia, and other Asian countries.

3.1.5 Pathology

The work of the Pathology group is oriented towards the development of resistance evaluation methods, and screening techniques for resistance to major diseases, determination of race variations, distribution of major diseases, and the screening of segregating and advanced lines for resistance. Emphasis has been given to soybean rust, anthracnose, downy mildew, bacterial pustule, soybean mosaic virus, purple seed stain, and root knot nematode. Host plant resistance is looked upon as a vital component of integrated disease management. Little attention has been given to chemical control. Disease resistance screening work has been carried out solely at AVRDC headquarters, and thus far this work has depended on natural disease incidence.

3.1.6 Entomology

The work of the entomology group is to develop an integrated pest management package based on host plant resistance, use of cultural practices, exploitation of natural enemies, and the application of insecticides. A great deal of work has been devoted to the identification of plant resistance to beanflies, pod borers, stinkbugs, foliage feeders, and aphids. Screening for pest resistance has relied on natural infestation, and, at times, induced infestation, as in the case of pod borer.

3.1.7 Physiology

Physiological work has focused on yield physiology, photosynthetic capacity of the plant in the early growth stages as it affects sink potential at flowering and the early pod setting stages, and screening for flooding and drought tolerance. It was determined that the storability of large-seeded varieties was readily affected by high temperatures, moisture content, and high seed oil content. Germination of large-seeded varieties was readily inhibited by six hours of water soaking, whereas small seeded varieties germinated even after three days of imbibition.
Crop management studies showed that green manuring with Crotalaria was sufficient to supply the nitrogen required to stimulate seedling growth prior to nodulation. The utilization of biological nitrogen by the soybean plant and the interactions between nitrogen fixation, soil nitrogen levels, and nitrogen fertilizer application are being studied using nodulating and non-nodulating isogenic lines. It was also found that incorporating straw or other organic matter which has a high C/N ratio resulted in significant increases in nodule formation but not yield. Mulching, or plowing in rice straw, greatly increased soybean yield when combined with nitrogen top-dressing. Deep plowing, accompanied by compost application, significantly increased both nodule formation and soybean yield.

Spacing studies in three seasons confirmed the superiority of 25 cm row spacing over 50 cm or 75 cm row spacing at optimum plant populations of 400,000 plants/ha.

Soil water stress imposed at various growth stages significantly reduced plant height. Pod-filling proved to be a critical stage in the determination of smaller seed size and lower pod number per plant.

Weed control studies showed the effectiveness of Metachlor against grassy weeds and Galex and Pendimethalin against grasses and broad-leaved weeds. The critical competition period at which soybean plants can compete with weeds was 30 days after planting. At least one weeding was found necessary at that time.

A senior microbiologist (seconded by INTSOY) is looking at rhizobial and micorrhizal activities in upland and flooded rice soils. The production of Rhizobia cultures in practical-sized operations using simple and available carriers is also being studied.

Farm surveys have been conducted in Taiwan, and results have revealed that farmers have a tendency to use more farm inputs than is necessary. A decline in soybean hectarage in Taiwan may have been caused by the loss of the competitive price advantage over crops such as adzuki bean.
tion Trial (ASET) network was established for the tropics and sub-tropics. AVRDC collaborates with the International Soybean Program (INTSOY) in conducting the ISVEX (International Variety Experiment) trials and with IRRI in testing new lines for management practices under rice-based cropping system. AVRDC also collaborates with IITA in varietal development work.

The soybean improvement program also works closely with the Center's bilateral projects in Korea, Thailand, the Philippines, and Taiwan in distributing promising breeding lines for evaluation and testing. The Korean program sends segregating materials to AVRDC for generation advance during that country's winter season. The AVRDC Vegetable Soybean Evaluation Trial network (AVSET) was established in Taiwan in 1983.

AVRDC has co-sponsored with other international agencies three symposia on soybean. One was held in Chiang Mai, Thailand in 1977 on the theme, "Expanding the Use of Soybeans in Asia and Oceania." The other symposia were held in Manila in 1977 (soybean rust) and in Tsukuba, Japan in 1983 (tropical and sub-tropical cropping systems).

3.1.10 Training

AVRDC has trained 102 soybean specialists from ten countries in the areas of production, research, and extension. Four research scholars have also conducted their thesis work at AVRDC.

3.1.11 Staff

There is a complement of scientists who are directly involved in soybean work (either full-time or part-time), though most have responsibilities to other programs.

There is one senior breeder, assisted by two full-time research assistants. The collaborating part-time scientists include: one senior entomologist and three assistants; two pathologists and four assistants; one physiologist and one assistant; one crop management specialist and one assistant; and one soil scientist and one assistant.

Altogether, 3.1 man years (MY) of senior staff time and 9.1 MY of regular staff time are devoted to soybean research per annum.

3.1.12 Achievements

AVRDC has assembled a large germplasm collection and developed advanced breeding lines which it has shared with
cooperators in 148 countries. Since 1980, six cultivars have been released by national programs in Honduras, India, Indonesia, Malaysia, Taiwan, and Korea. Hectarage and distribution are not known, so it is premature to assess their impact. Other national programs have used a number of AVRDC lines in their breeding programs.

A significant contribution of AVRDC to world soybean research is the identification of germplasm materials and breeding lines which carry desirable traits for greater adaptation and tolerance to adverse conditions. They are:

(a) Two high yielding accessions that can be used for yield-boosting purposes, one from Indonesia and the other from Taiwan, which produce a large number of pods.

(b) Selections that are relatively yield-stable over changing growing seasons.

(c) Lines that are less sensitive to both photoperiod and temperature fluctuations.

(d) Advanced selections that carry resistance to bacterial pustule and downy mildew.

(e) Accessions or breeding lines which carry resistance to soybean rust, soybean mosaic virus, purple seed stain, downy mildew, and root knot nematode.

(f) Accessions and breeding lines which carry resistance to beanflies, podborer, stink bug, aphids, and leaf feeders.

(g) Accessions that are tolerant of flooding and drought.

(h) Accessions suitable for use as a green vegetable.

(i) Accessions from Indonesia that possess high degrees of seed storability and viability.

If these lines prove their worth in other countries, they will be invaluable as potential varieties or breeding stocks for use in variety development programs.

3.1.13 Constraints

Much of the work on screening and evaluation of germplasm materials and the development of breeding materials and
management practices has been confined to the environments of Taiwan, and results are therefore likely to be of restricted value in other regional environments.

The host resistance factors that have been identified are specific to the races of pathogenic organisms and pests occurring in Taiwan. Thus, there is a need for AVRDC to assist national programs to verify the reaction of resistant materials and to test the germplasm against the endemic strains found in tropical Asia. Breeding materials and technological packages have to be fully evaluated in different ecological zones.

3.1.14 Future Plans

Germplasm

The germplasm materials are being individually described and catalogued for a data base retrieval system. Germplasm will be made available to national breeding programs for various screening purposes in the regions where specific biological problems are found.

Breeding Programs

Emphasis will be directed to the adaptation of soybean cultivars to various macro-climates and cropping systems. Cultivar evaluation will be carried out under a soybean/maize intercropping system.

The program will continue to combine into varietal entities as many desirable attributes as possible, including multiple disease and pest resistance, high yield potential and stability, resistance to shattering, and improved seed quality. Physiological studies hope to identify the nature of drought and flooding tolerance, photoperiod and temperature insensitivity, and yield physiology.

A pest management system will be developed based on the level of multi-varietal resistance to pests and diseases that can be acquired. Possibilities for selecting and developing varieties with greater weed competitiveness and response to minimum and optimum levels of inputs will be studied.

Entomology

The entomology group will continue to assist in screening for resistance to various pests in Taiwan and other countries. To augment natural insect pest
populations, certain pests will be reared in the laboratory on artificial diets. Mechanisms of resistance will be studied. Tests for beanfly and borer resistance will be carried out in selected locations in Indonesia.

Pathology

The pathology group will continue to determine the stability of available resistances and their utility in breeding and selection programs. It will also work to standardize disease assessment methods and to improve screening techniques and selection criteria for use by cooperators. Joint screening for rust and anthracnose resistance as well as chemical control studies will be carried out in Thailand, the Philippines, Indonesia, and Brazil.

Crop Management and Soils

The management group will look into different components of crop management in growing soybeans in multi-cropping and rotation systems. Approaches to soil, water, and crop management will take a different perspective when viewed in the context of the whole cropping system or in rotational systems in upland as well as rice-based soils.

International Cooperation

The search for new genetic materials that carry different desirable characteristics such as high yield, early maturity, disease and pest resistance, and superior eating quality will be expanded through formal testing networks.

The proposed networks included:

(a) AVRDC Soybean Evaluation Trial (ASET)
(b) AVRDC Vegetable Soybean Evaluation Trial (AVSET)
(c) AVRDC Soybean Management Input Trial (ASMIT)
(d) AVRDC Soybean Rust Tolerance Nursery (ASRTN)
(e) AVRDC Soybean Beanfly Resistance Evaluation Nursery (ASBREN)
(f) Asian Soybean Improvement Network (ASIN) - joint effort with IITA, INTSOY, UNDP, IAEA and the European Cooperative Soybean Network (ECSN).

Assessment and Recommendations

The Panel acknowledges the dedication and outstanding work of the soybean improvement team in making its contribution
felt world-wide in a relatively short period of time. The soybean research team has a well thought out plan of what needs to be done in the future. The Panel would like to reiterate its observations and recommendations in the following areas:

**Germplasm Collection**

The existing germplasm collection provides the building blocks on which breeding materials are synthesized. The collection is weak in terms of mainland Chinese and Indo-Chinese accessions.

The Panel supports the efforts being made to obtain further collections from other world repositories through the assistance of the IBPGR.

The Panel also recommends that germplasm materials that have been identified as possessing outstanding attributes should be constituted into a "working collection" that is properly characterized and catalogued. Printed information should be sent to national programs.

**Breeding Programs and International Evaluation**

Soybeans in Asia are grown in three systems: upland monocropping, upland intercropping, and rice-based cropping. Intercropping is complicated by partial shading and nutrient competition. Rice-based soybean cropping involves zero tillage, moisture stress, and the need for supplementary irrigation.

The Panel recommends that in the final stages of varietal evaluation, simulated conditions of intercropping and paddy cultivation be superimposed.

Selection procedures for different physiologic and agronomic traits have relied for the most part on visual and intuitive judgment. Some form of objectivity is needed to make current selection procedures more precise. AVRDC has the expertise to establish selection indices by agreement of the physiologists and breeders, in particular.

The Panel recommends that "selection indices" be established for critical traits that make for broad adaptation, stability in yield, and tolerance to soil stresses in tropical and sub-tropical climates.

Joint planning strategies among Asian scientists and the testing of basic materials in different environments, and
where indigenous strains of pests and diseases are present, would be useful in developing varieties for wide adaptation and in expediting varietal improvement.

The Panel recommends that joint planning workshops and international monitoring tours of screening trials among Asian scientists be provided as funds allow.

Now that a number of lines have been identified which carry separate desirable attributes (high yield, yield stability, photoperiod insensitivity, rust and pest resistance, flooding and drought tolerance, and high seed germination) efforts should be made to combine these traits in as many combinations as possible in the shortest period of time. The situation requires a breeding strategy and phasing to accomplish these objectives. Two breeding methods that seem appropriate and that are worthy of consideration are the "backcross" and "diallel selective mating" methods. The latter would provide for a pyramidal recombining process, utmost diversity, and wide recombinations. The segregating materials would be broad-based and could be distributed to national programs to be screened under their own conditions. Accordingly, the Panel supports the move that has been initiated to synthesize and distribute broad-based segregating populations to national breeding programs for their own selection purposes.

Entomology and Pathology

Varietal resistance to rust, beanfly, and pod borer is attainable, but rather elusive because of host-race specificity and complex inheritance.

The Panel is in complete accord with AVRDC's plan to conduct joint screening for resistance to rust, beanfly, and borer in selected Asian countries. The Panel further recommends that joint efforts be mounted to study and establish resistance against yellow mosaic virus disease, a pathogen which poses a threat to the developing soybean industries on the Indian subcontinent.

Crop Management

The crop management groups may well adjust some of its activities to the general objectives of the soybean program in evolving management practices for low, moderate, and high input production. Varieties are being developed which have built-in resistance to pests and diseases, tolerance to unfavorable environments,
and response to low and high inputs. It may be worthwhile to complement varietal improvement programs with studies on responses to different levels of crop management and to determine production potentials in economic terms. Appropriate methodologies for such tests are needed. The Panel therefore recommends that efforts be strengthened to develop low and high input technologies as options for the varied clientele of the farming communities of Asia.

3.2 Mungbean

3.2.1 Background

"The mungbean is an ancient and well-known Asian legume crop. It is an excellent source of protein and it is eaten in many forms, including bean sprouts, green beans, boiled dry beans, and noodles. Mungbean has never received the kind of research attention that has been directed to most other important food crops. Yet, through a concerted large-scale research program, its yield potential, now only about 1.5 metric tons per hectare, might well be doubled. This could be achieved by breeding varieties that not only make more efficient used of solar energy and soil nutrients but that are more resistant to insect and disease attack (AVRDC Annual Report 1972-1973).

Mungbean has the shortest maturity span of all the legume crops and can therefore be planted following cereals in a number of cropping systems. It is also an excellent green manure crop and can be used as animal feed.

Mungbean is believed to be native to the India-Burma region, and it is grown mostly in Asia. It has recently been introduced to the United States, Central America, Australia, and other countries.

World production is estimated at about 1.4 million tons harvested from 3.4 million ha (60% of all production is based in India). Average yield is approximately 0.4 t/ha, ranging from 0.3 to 1 t/ha.

Native mungbean cultivars are only partly domesticated, and most of these are low yielding due to poor genetic potential. Furthermore, mungbean pods shatter easily and mature at different times, which in turn requires multiple harvesting by hand. The crop is also susceptible to diseases and insects, as well as various environmental stresses.

Beanfly, bruchid, and pod borer are the most important mungbean insect pests. Cercospora leaf spot (CLS) and
powdery mildew (PM), which cause yield losses of 58% and 40%, respectively, are the most important diseases in all producing regions. Mungbean yellow mosaic virus is important on the Indian subcontinent, as is scab in Indonesia.

The close relatives of mungbean (Vigna Radiata) are blackgram (V. mungo), rice bean (V. umbellata), adzuki bean (V. angularis), and moth bean (V. aconitifolia), each of which belongs to the subgenus Cerátotropis. Some of these crops can be used as sources of pest resistance, improved nutrition, and other desirable characteristics.

3.2.2 Objectives

The primary objectives of the AVRDC mungbean program is to develop cultivars with high stable yield, early and uniform maturity, resistance to CLS, PM, and beanfly, low sensitivity to day-length and temperature, lodging tolerance, and good seed appearance.

A major effort will be made in developing lines with specific characteristics that enable national programs to combine desirable lines that fit specific local conditions. In some countries where breeding programs have not yet evolved, advanced lines that are appropriate for release will be provided for in-country evaluation. The International Mungbean Nursery (IMN) will be strengthened, and an AVRDC Powdery Mildew and Cercospora Leaf Spot Screening Nursery (APCSN) will be initiated.

Scientists also hope to develop superior cultivars through interspecific hybridization with blackgram, which has several desirable traits not found in mungbean, e.g. disease and insect resistance and better nutrition.

The mungbean program is also mandated to develop cultural practices and appropriate integrated crop management systems.

The chemistry program will assess the quality of elite mungbean lines, improve the nutritional quality of mungbean protein, improve processing techniques for noodle making, and attempt to increase the utilization of mungbean protein.

3.2.3 Germplasm Collection, Evaluation, and Enhancement

The collection of mungbean germplasm started in 1972. Thus far, 5,112 accessions have been collected from 51 countries, the largest collection of its kind in the world. AVRDC has been designated by the IBPGR as the world repository for mungbean, and receives support from IBPGR for mungbean characterization.
Evaluation of the collection has found many valuable traits, including:

(a) High yield, earliness and/or uniform maturity have been identified in accessions V 1381, V 2184, and V 3476. These materials have been widely distributed to cooperators and have also been used as parents for 57 breeding lines.

(b) Four cultivars have been identified as being insensitive to day length and temperature.

(c) Eighteen PM resistant and six CMS resistant accessions have been identified; four of these accessions have combined resistance.

(d) Three accessions with moderate resistance to bean flies have been identified, as were two lines that are highly resistant to bruchids, and one line with moderate levels of resistance to podborers.

(e) Five accessions with moderate levels of flood tolerance were identified.

(f) Blackgram was identified as a genetic source for resistance to important diseases and insects, tolerance to environmental stress, resistance to shattering, and, in particular, higher methionine content.

A total of 3,949 crosses have been made to combine various desirable traits. Exploration trips will be conducted in the future with emphasis on mainland China, Vietnam, and Burma.

3.2.4 Breeding

General

(a) AVRDC accessions and lines have been released by national programs in Australia, Costa Rica, Fiji, India, Indonesia, Korea, Sri Lanka, Taiwan, and Tanzania.

(b) Six mungbean lines with acceptable compatibility to blackgram have been identified to serve as genetic bridges between the two species.

(c) AVRDC has distributed 14,302 accessions and 10,365 breeding lines to 129 cooperators in 48 countries. These materials are widely used as
breeding stocks by national programs in Asia, Australia, and the USA.

Plan of Work 1985-90

(a) The combining of high yields, early maturity, and resistance to CLS and PM.

(b) The accumulation of genes for high yield and the development and evaluation of near-isogenic lines for lobed leaflet and multiple leaflet characteristics.

(c) The improvement of present levels of resistance to CLS and PM.

(d) The incorporation of beanfly resistance.

(e) The recovery of highly fertile lines that can be crossed with blackgram.

(f) Breeding for resistance to selected viruses, root disease, and drought.

(g) The integration of high methionine content and resistance to bruchids and pod borers from blackgram.

3.2.5 Pathology

The ultimate goal of the mungbean pathology program is to develop cultivars with stable, multiple disease resistance, as well as appropriate disease management practices that complement this resistance. Powdery mildew and Cercospora leaf spot have been the chief concerns; root disease complexes, mungbean viruses, and seed- and soil-borne diseases are also important.

Accomplishments (not including the development of CLS and PM resistant lines)

(a) Potential losses caused by PM and by CLS were found to be potentially higher than 40% for PM and 58% for CLS.

(b) A study on the biology, epidemiology, and media required for culturing CLS provided an excellent understanding of the disease and its development.

(c) Mungbean mottle virus was identified as a new virus with potential yield losses totalling 30%.
Several accessions were found to be highly resistant to the disease, and methods for purification of the virus have been developed.

(d) Several viruses that cause mottle, mosaic, and leaf crinkle have been isolated. One virus is seed-transmitted and is serologically related to CMV.

(e) Root-knot nematode resistance was found in at least 29 accessions and possibly also in another 12 accessions.

(f) A complex of several root pathogens has caused problems in AVRDC field plots which were thought to be due to allelopathy.

(g) Fungicide screening found Daconil to be effective against CLS and Milcurb against PM.

(h) A mungbean leaf blight was identified in Taiwan.

Work Plan

The future work plan for mungbean pathology includes: root disease complex (priority 1), mungbean viruses (priority 2), CLS (priority 3), PM (Priority 4), seed-borne and soil-borne pathogens (Priority 5).

3.2.6 Entomology

Objectives

(a) The identification of sources of resistance to mungbean insect pests and the incorporation of resistance into advanced mungbean breeding lines.

(b) The study of insect-plant interactions, including beanflies, podborers, podfeeders, stinkbugs, and bruchids.

Strategies and Priorities

(a) Screening germplasm for resistance to various insect pests in Taiwan and other target countries.

(b) Augmentation of insect pest populations for testing.

3.2.7 Physiology

Objectives

(a) Assessment of the physiological principles that
influence high yield and their application to yield improvement.

(b) Assessment of the physiological basis of drought and flood resistance and their component traits in relation to varietal differences.

Accomplishments

Yield Physiology

(a) Yield limitations were found to be mostly due to source rather than sink strength.

(b) Pod setting was found to be influenced by plant hormones.

(c) A model was developed showing the partitioning of dry matter in relation to yield.

(d) Low light intensity and high temperatures were found to promote flower and pod abscission.

(e) Mungbean yields were found to be highly correlated with the number of pods per unit area.

(f) Various cultivars were found to differ in photosynthetic rate, chlorophyll content, and net assimilation rate.

(g) Response to photoperiod was found to occur at the preflowering and flowering stages.

(h) Yield increases were found to be promoted by kinetin, ABA, and BNOA.

Drought Tolerance

Various studies were conducted on photosynthetic rate, diffusive resistance of the stomata to CO₂, flowering, yield reduction, and drought sensitivity.

Flood Tolerance

Several lines showed various levels of flood tolerance; flooding was generally found to delay flowering and maturity and to reduce yield.
Physiology Work Plan

(a) Rapid canopy development through cultural techniques.

(b) Development of selection criteria for rapid plant growth, efficient dry matter accumulation, and partitioning to seed.

(c) Evaluation of yield performance of advanced breeding lines in relation to growth parameters and yield components.

(d) Studies of hormonal balance in relation to uniform maturity, efficient dry matter partitioning, pod setting, sink strength.

(e) The selection of synthetic growth regulators.

(f) The development of selection criteria for drought and flood tolerance.

(g) The evaluation of drought and flood tolerant breeding lines.

3.2.8 Chemistry

Objectives

(a) Utilization of protein fractions in noodle making and development of a dry process of fractionation.

(b) Protein nutrition improvement by means of interspecific crosses with blackgram.

(c) Quality evaluation of elite mungbean breeding lines.

Accomplishments

(a) A dry process of air classification for separating mungbean starch and protein was developed to conserve the protein usually lost in extracting starch for noodle making. The protein, when use for baking bread, resulted in high protein bread loaves.

(b) Mungbean protein was found to be easily digestible, but low in biological value due to low S-containing amino acids, methionine and cystein. Little variation was found within the germplasm
collection. Analysis of the F₂ progeny of interspecific crosses between the mungbean and blackgram showed higher levels of free methionine and β-glutamyl-methionine than mungbean. Microbiological assay methods were developed for determining methionine content, as well as for digestibility evaluation. Tannin content of blackgram seed showed a negative correlation with protein digestibility.

3.2.9 Crop Management and Soil Science

Areas of Concentration

Soil fertility, weed control, nitrogen contribution from legume crops, and the effect of soil moisture on the yield of mungbean.

Accomplishments

(a) The critical period for weed competition in mungbean fields was found to occur 30 days after sowing. Several herbicides have been identified for use in different seasons.

(b) Chloropicrin treatment and flooding eliminated allelopathic damage; one month of flooding in the field doubled the yield of mungbean compared with non-flooded plots.

(c) The highest yields were obtained in plots which were irrigated once at 30 days after planting. Excess water was found to reduce yield.

(d) Spacing between rows at 25 cm and within row at 10 to 20 cm were found to be optimal for populations of 400,000 plants/ha.

3.2.10 International Testing and Cooperative Programs

(a) International mungbean nursery - the IMN set includes cultivars recommended by national programs and AVRDC. IMN sets are distributed to cooperators in various national programs each year, and serve as a means of disseminating superior genotypes and generating information on the range of adaptation.

(b) Outreach programs in the Philippines, Korea, and Thailand evaluate AVRDC yield trial sets, select segregating populations, and test disease resistant selections.
(c) Bilateral cooperative programs activities:

Philippines - Institute of Plant Breeding, UPLB and IRRI; AVRDC provides promising selections for screening in the Asian Cropping Systems Network.

Republic of China - Tainan DAIS; AVRDC supplies entries for the Taiwan Mungbean Regional Yield Trials.

India - Indian Agricultural Research Institute - Pakistan - Nuclear Institute of Agriculture and Biology; AVRDC hybridizes high yielding, CLS-PM resistant lines with yellow mosaic virus resistant lines and supplies F2 seed.

Indonesia and other countries - promising selections, genetic resources, segregating materials, and mungbean-black gram interspecific derivatives are distributed to researchers through formal or informal arrangements.

(d) Thailand and the Philippines; joint screening and evaluation of materials resistant to CLS and PM.

(e) Taiwan and Germany; cooperative studies on mungbean viruses.

(f) Indonesia and Thailand; beanfly resistance cooperative programs.

3.2.11 Staffing

Ten senior scientists and 15 research assistants (RA) are involved in the mungbean program: 1 plant breeder (0.4 MY) (Man year) with 2 RAs (2 MY), 2 plant pathologists (0.4 MY) with 4 RAs (0.9 MY), 1 entomologist (0.2 MY) with 3 RAs (1.5 MY), 1 plant physiologist (0.1 MY) with 1 RA (0.1 MY), 1 biochemist (0.2 MY) with 1 RA (0.1 MY), 1 crop management specialist (0.2 MY) with 1 RA (0.5 MY), 1 soil scientist (0.2 MY) with 1 RA (0.5 MY), 1 seed technologist (0.4 MY), and 1 training officer (0.1 MY). All the senior scientists and most of the junior scientists are also involved in other programs.

3.2.12 Facilities

Facilities for the mungbean program are generally adequate. However, more land and equipment are needed (see Constraints).
3.2.13 Constraints

Breeding

There is a need to enrich the mungbean germplasm, especially with accessions from mainland China, Vietnam, Burma, and Bangladesh. Some basic information is not yet available i.e. the physiological aspects of the relationship between yield and plant morphology, a basic understanding of reproductive development for breeding for uniform maturity, the races of CLS and PM pathogens and the environmental factors that affect these diseases, interaction between photoperiod and temperature, and the cause of hybrid sterility in mungbean-blackgram crosses.

The genetic sources of some desirable traits are insufficient for uniform maturity and resistance to major insects.

Present screening techniques for tolerance to extreme temperature and moisture and for insect resistance is not practical for use by breeders.

Pathology

Information is lacking on the genetics of resistance and the environmental influence on CLS, PM, and the root disease complex. Further difficulties have been encountered in identifying mungbean viruses due to the fact that more than 20 viruses have been reported; of these only a few have been characterized and symptoms vary at different temperatures.

Entomology

Mungbean accessions with resistance to one species of insect may not be resistant to other species, or vice versa. Even within a single species, different biotypes may be present. There is a need to develop cultivars resistant to both pith and epidermis feeders.

Sources of resistance to podborers and bruchids are found in black gram, but it is difficult to cross blackgram with mungbean. Viable seeds rarely develop beyond the F₃ stage.

Insect population pressure is lower in Taiwan than in Southeast Asia, and this makes identification of truly resistant accessions difficult without confirmation in other countries.
Entomology Facilities and Personnel Requirements

An insect physiologist, additional experimental land or breeders, controlled environment facilities, a greenhouse and various equipment for Pathology and Physiology.

3.2.14 Assessment and Recommendations

The Panel feels that the initial success of the mungbean program is commendable. Yield potential has been increased to about 2.7 t/ha from 0.3 to 1 t/ha. Plant architecture has been changed; resistance to CLS and PM has been developed and incorporated into advanced lines; pod maturity has reached 80% at first harvest; and plants are less photosensitive than before. The program was able to assimilate the results of some national programs such as those from the Philippines.

The large germplasm collection enables screening and selection of many desirable traits. Accessions from Philippines have been shown to be very productive, and those from India and Bangladesh have good resistance to diseases and insects. Some accessions have been released as cultivars in other countries. The team strongly urges that additional accessions be acquired from mainland China, Vietnam, Burma, and other countries.

Selection for non-photosensitivity, tolerance to high and low temperatures, flooding and drought, early and uniform maturity and for wide adaptability are required. However, as the nature of the biological stresses differs in various regions, final selections should depend on national programs. The Panel encourages AVRDC in its program to supply a wide range of breeding lines to national programs at various stages of selection.

Mungbean is often grown under low input in rotation with rice or other crops. The Panel feels that more yield potential estimates should be made under farmer's conditions to determine appropriate inputs.

Interspecific hybridization between mungbean and black gram raises a great deal of hope for the transfer of more useful traits, i.e. insect and disease resistance and improved nutrition. The Panel suggests that a greater effort be made to realize the benefits that hybridization may offer.

Resistance to the two major diseases, powdery mildew and Cercospora leaf spot, have been incorporated into many
cultivars and breeding lines. The stability of the resistance in different locations is, however, not certain. The team encourages studies on the physiology of fungi races and the genetics of resistance to provide greater insight into these problems.

There are many mungbean viral diseases that are difficult to study due to a lack of detailed information. The Panel recommends that a distribution and damage survey be conducted in major mungbean growing areas.

The International Mungbean Nursery and the many bilateral cooperative programs established by the Center suggest that there are considerable contacts between AVRDC and national programs. The Panel encourages further exchange of information and materials, as well as personal visits. Annual meetings of mungbean workers in Asia would be desirable if funds permit.

The Panel has considered the proposal that the mungbean program be evaluated with respect to the question of the advisability of phasing it down after three to five years. The Panel agrees that the interspecific hybridization program should be continued until its potential is established or it is abandoned, and that the international program would need to be expanded to transfer the new mungbean technology to client countries.
4. HORTICULTURAL PROGRAM

4.1 Chinese Cabbage

4.1.1 Historical

Chinese cabbage is a temperate crop that originated in China prior to the fifth century. There is a particularly strong demand for Chinese cabbage in tropical and subtropical, Southeast Asian countries that have substantial Chinese populations. Consequently, there is a need for the tropical adaptation of Chinese cabbage. The merits of Chinese cabbage as a delicious and nutritious vegetable, together with its potential for increased utilization throughout the tropics, have resulted in its being selected as a mandate crop for research at AVRDC.

4.1.2 General Objectives

The primary requirements for tropical adaptation are the ability to produce a good yield of marketable heads under high temperatures and frequent heavy rain showers, together with resistance to the major diseases and pests which limit plant growth. To complement the genetic improvement of tropically adapted cultivars of Chinese cabbage, there must also be development of crop management practices that ensure optimal production potential.

4.1.3 General Structure and Content of the Program

The Chinese cabbage program requires the participation of a number of specialized disciplines and resources focusing on carefully determined, specific objectives. The basic resource underlying the genetic improvement of the crop is the germplasm collection. From this collection, desired genetic variants are identified and recovered through vigorous screening procedures, recombined using appropriate breeding strategies, evaluated under diverse crop management regimes, and stabilized in seed production schemes for distribution to farmers.

Germplasm Bank

The need for a broad-based germplasm resource in Chinese cabbage and related crucifers led to the early development of a substantial collection of cultivars from around the world. Though the AVRDC collection consists of both open pollinated and F₁ hybrids, mainly from temperate sources, it is viewed as a valuable and diverse resource containing desirable phenotypes which may be recombined in a breeding program. Early
collections concentrated on locally adapted Taiwan cultivars, as well as large collections from Korea and Japan. A major, largely uncollected reserve of variation in Chinese cabbage exists in mainland China.

The International Board for Plant Genetic Resources (IBPGR) is providing funds for the multiplication and characterization of the open pollinated Chinese cabbage accessions.

Germplasm Development

Because of the readily available supply of phenotypic diversity within the heading forms of Chinese cabbage contained in the AVRDC germplasm collection, there is little need to seek additional adaptive phenotypes outside of the heading types of *B. campestris* ssp. pekinensis.

Breeding Program

Essential to the breeding objectives of high yielding, heat tolerant, multiple disease and pest resistant cultivars with broad adaptation is the need to provide reliable and reproducible screens from which desired plant phenotypes can be selected. Among the screens that have been used in the Chinese cabbage program are the following:

(a) The growing of all accessions in the field during the hot and humid summer season to determine those which can provide marketable heads.

(b) The measurement of head firmness as a criterion of marketability.

(c) The measurement of head weight as an indication of yield potential.

(d) The inoculation of seedlings with various strains of turnip mosaic virus prior to transplanting into the field, and the selection of virus resistant survivors.

(e) The inoculation of young plants growing in the field with soft rot bacteria, *Erwinia carotovora* and the selection of individuals from lines showing reduced soft rot.

(f) The growing of accessions in a downy mildew (*Peronospora parasitica*) field nursery for evaluation and selection of resistant individuals.
(g) The creation of field infestations of diamond back moth (Plutella xylostella), cabbage webworm (Hellall undalis), aphids (Myzus persicae), cabbage looper (Tricoplusia ni), and flea beetle (Phylotreta striolattta) and the selection of resistant individuals.

(h) The use of high air temperature to augment flooding stress in the selection for flooding tolerant individuals in the greenhouse and field.

(i) The use of cold exposure (5°C for 20 days) to seedlings as a means of identifying heat tolerant plants. Heat tolerant plants are induced to flower more rapidly under the cold treatment than heat sensitive individuals.

By using the summer growing season as the primary screen for heat tolerance and general adaptability, a number of heat tolerant lines from Taiwan have provided the basic germplasm upon which specific improvements have been made.

The basic breeding approach in the Chinese cabbage program has been to increase diversity by making selected crosses between heat tolerant lines and unrelated sources carrying disease resistance. Following two or three cycles of recurrent and mass selection for heat tolerance and multiple disease resistance, interbreeding populations were produced from which inbreds were developed and evaluated as parents for F1 hybrid production. From the same population that hybrids were developed from, closely selected open pollinated (OP) stocks were also selected to be used as cultivars in programs not wishing to, or unable to produce F1 hybrids.

Another approach in the production of F1 hybrids is the use of cytoplasnic male sterility (CMS) derived from radish and Brassica juncea.

International Testing

Experimental F1 hybrids and open pollinated lines are routinely distributed for testing as part of the AVRDC outreach and bilateral programs in Korea, Taiwan, Thailand, and the Philippines, and are also dispersed widely throughout the tropics. Four inbreds have been used in the Korean breeding program of the Office of Rural Development. AVRDC Hybrid #62 was released to
Taiwan farmers as "ASVEG #1" in 1982 and was also approved by the Philippines Seed Board and named "Renya Elena" in 1983. Two open pollinated lines were named "Eperanza" and "Corazon" in the Philippines in 1982, and two open pollinated lines showing promise in Nagasaki and Okinawa in Japan, are to be named in an official release in 1984. AVRDC hybrids and open pollinated lines have also shown promise in the United States, Fiji, the Seychelles, Tahiti, and Haiti.

Maintenance of Recommended Varieties and Seed Production

The AVRDC program is prepared to provide the technical training and consultation necessary to ensure that seed production of Chinese cabbage can be accomplished in those countries wishing to establish a seed production capability. AVRDC also provides a "back up" position in resupplying parental stocks in the event of loss.

Pathology

From the outset of the Chinese cabbage program, pathologists have cooperated closely with the breeders in providing selective screening for resistance against Turnip Mosaic Virus (TuMV). Seedlings are inoculated with indigenous strains of TuMV and resistant or immune segregants are selected for breeding purposes. By continuing to provide screening services which take into account the increasing virulence complexities in the indigenous strains of TuMV found in Taiwan, the virologist is providing an invaluable service to the Chinese cabbage breeding program. Furthermore, by maintaining the capability of monitoring TuMV strains and other viruses found in Chinese cabbage and other crucifers in those countries where AVRDC lines are being grown, information useful in selecting the most desirable lines of Chinese cabbage for those regions may be obtained.

For downy mildew resistance, breeding resistant cultivars progressed satisfactorily through the effective use of field screening in a downy mildew nursery. Downy mildew is endemic in AVRDC's region, and during the wet summer season epidemics can be easily created by planting adequate numbers of susceptible "spreader rows".

Bacterial soft rot caused by Erwinia carotovora is a disease that has always been associated with the production of Chinese cabbage grown under high tempera-
tures. Heat tolerant lines are normally grown under temperatures that are highly favorable for soft rot. Although all breeding lines have been routinely inoculated in the field with bacterial soft root, the incidence of disease occurs erratically and is frequently more severe in non-inoculated controls than in inoculated lines. The etiology of soft rot is not fully understood, nor is it clear whether mechanical injury or flooding plays a predisposing role. One general observation is that early maturing types appear to escape soft rot damage.

Entomology

Among the various insect pests of Chinese cabbage, diamond back moth is the most numerous and serious throughout tropical Southeast Asia. Cabbage looper, cabbage worm, and striped flea beetle are secondary pests but may cause severe damage in limited locations. Cabbage webworm is serious only during the hot and humid months, whereas aphid infestations occur primarily in the cool months.

Systematic screening of the Chinese cabbage germplasm collection and other crucifers to all of the above insects has failed to identify useable levels of resistance. With the exception of two accessions of B. campestris ssp. parachinensis which show low levels of resistance to diamond back moth, and four B. juncea accessions with aphid tolerance and one B. juncea with a low level of resistance to cabbage webworm, there is little hope of utilizing genetic resistance to insect pests in the breeding program. Strategies to cope with various insect pests are centering on the principles of integrated pest management, with research taking into account the need replace broad spectrum insecticides with narrowly targeted ones that could permit the build up of effective parasite and predator populations of certain crucifer pests. The use of reflective mulches and fine mesh nets for the control of aphids carrying TuMV to Chinese cabbage seedbeds are also under study.

Physiology

Physiology has made a number of important contributions to the Chinese cabbage program by identifying those aspects of plant growth and development that are responsive to the stresses associated with growth and reproduction under tropical conditions. Through a critical examination of the relationship between cool
temperatures and flowering response, an effective screening procedure for the selection of early bolting heat tolerant types was made possible. Use of this method permitted the advancement of selections for heat tolerance during the cool season and contributed significantly to the rapid progress made in this program. Numerous physiological studies on the mechanism associated with heat tolerance have provided insights into the complexities of the phenotype. Present studies directed at understanding the physiological basis for flooding tolerance may lead to efficient ways of screening for this character.

Crop Management

A number of crop management practices have been investigated in conjunction with the development of the heat tolerant Chinese cabbage lines. The first of these was the determination of 30 cm as the optimum bed height for producing Chinese cabbage in periods of high rainfall. In transplanting experiments, "slot" nursery planting boxes were found to produce the highest yields of marketable heads compared to plants from soil flats. In a set of experiments extending over three years to examine the effects of leaf-tying of summer-grown, non-heat tolerant Chinese cabbage, it was found that loosely tying the outer heading leaves between 30 and 33 days after transplanting increased the yield of heat sensitive cultivars over that of non-tied heat tolerant cultivars.

Training

The Chinese cabbage program has served as the training base for both research workers and production technologists from many nations. Most of these trainees have returned to positions in their national programs, and many continue to work with Chinese cabbage.

Communications

Many research papers on Chinese cabbage have been produced by the various discipline-oriented teams and published in refereed journals. The AVRDC Information Office has published a number of technical publications on Chinese cabbage cultivation. An important AVRDC publication is the book Chinese Cabbage, comprising the proceedings of the First International Symposium on Chinese Cabbage held in Tsukuba Japan in 1980.
4.1.4 Means and Facilities

Personnel

The personnel resources devoted to all aspects of the AVRDC Chinese cabbage program are substantial. Approximately 2.9 MY (man years) of senior scientific personnel (including 1 temporary MY in germplasm funded by IBPGR) and 4.9 MY of research assistant support totalling 7.8 MY are dedicated to Chinese cabbage. The disciplinary inputs of total MY's are allotted as follows: 1) breeding, 1.4 MY, 2) pathology, 1.6 MY, 3) entomology, 0.7 MY, 4) physiology, 0.5 MY, 5) chemistry, 0.1 MY, 6) crop management, 0.5 MY, 7) soils, 0.6 MY, 8) germplasm and seed laboratory, 2.0 MY and 9) training, 0.3 MY.

Overall, the program is adequately staffed to operate within the established working plan.

Land and Equipment

The availability of land at AVRDC is adequate for the needs of the program in evaluating adaptive performance of segregating progenies and advanced lines under hot humid tropical conditions. The acquisition of a cool temperature highland site would significantly advance the program by permitting seed increases of advanced lines during the summer. There is also an urgent need for additional semi-permanent net-house construction for population increase. Substantially constructed greenhouses or screen houses which permit isolation and the raising of virus infected plants and aphids, would significantly enhance the pathology program. Likewise, additional limited environmental control facilities for research on downy mildew would be of benefit to the overall program.

4.1.5 Achievements

Though the achievements of the Chinese cabbage program should ultimately be judged by the degree to which they have contributed to improved farm production in nations utilizing the AVRDC cultivars, in the 10 years that the program has been under way a number of specific objectives have been met. The development of tropically adapted, multiple-disease-resistant, heat-tolerant hybrids and open pollinated lines has been achieved. The general acceptance of several of these lines and their licensing and release as
named cultivars in various tropical countries is a significant achievement. The development of suitable cultural practices to support the production of the tropical types of cabbage is an important contribution, complementing the production of the new plant types.

4.1.6 Constraints

Apart from the budgetary constraints limiting the provision of equipment and supplies, the only major constraints to the overall program are the requirements for major facilities and a cool climate site as discussed under the section on land and equipment.

4.1.7 Future Plans

The development, release, and wide acceptance of superior Chinese cabbage cultivars represent a substantial beginning in the general Chinese cabbage improvement program. The breeding program, as now structured, will continue to sustain the identification and incorporation of improvements into the crop. Furthermore, the technology for stabilization of the improved phenotypes either as F₁ hybrids or as open pollinated cultivars has been established, and the research underway on synthetic population development and cytoplasmic male sterility should provide even simpler and more reliable means of producing seed of the desired types than current methods.

Germplasm Bank

The germplasm bank will continue to serve as an important source of breeding material in the future, particularly as new strains of viruses or downy mildew are identified for which resistance does not exist in the breeding program. As new screening methods for evaluation of horizontal resistance to TuMV, downy mildew, or soft rot are devised, these may be used to rescreen the accessions in the germplasm bank to identify new sources of resistance. The storage capabilities of the germplasm bank will be used increasingly to provide medium range (10-20 years) storage of important parental inbreds, hybrids, and improved populations that represent reservoirs of recombined useful traits.

Breeding Program

Chinese cabbage breeding in the future will continue to draw upon the variation in the heading forms of B. campestris ssp. pekinensis. Objectives will be to
develop better disease resistant hybrids through open pollinated breeding populations subjected to cyclical selection for heat tolerance and disease resistance, using mass and other population breeding methods.

**International Testing**

Advanced open pollinated lines and F₁ hybrids will continue to be tested as widely as possible through cooperators in national programs. As additional factors for disease resistance and wider adaptibility are incorporated into advanced materials, it is expected that AVRDC lines would be grown more widely throughout the tropics.

**Pathology**

Future research on TuMV will concentrate on the development of a practical and more efficient screening technique for the seedling stage, on the identity and maintenance of new and different TuMV strains, and on the search for new sources of resistance.

Research with downy mildew will focus on evaluating the pathogenic variability in the organism and the possibility of detecting horizontal resistance by devising methods that will permit both quantitative and differential evaluations of the host-pathogen interactions.

Improved methods for evaluating soft rot resistance will also be investigated and applied in the breeding program.

**Entomology**

The objective of future research in entomology will be aimed at developing an integrated pest management program in Chinese cabbage based on the possible application of biocontrol agents, selected application of pesticides, and appropriate cultural practices. If useful sources of insect resistance are detected via screening programs on newly acquired crucifer accessions, these will be incorporated into breeding lines for eventual integration into the pest management program.

**Physiology**

Efforts will continue in physiology to identify physiological and morphological factors affecting flooding tolerance, with the aim of developing flooding tolerant lines or cultivars.
Assessment and Recommendations

The Panel has been impressed with the effectiveness of the Chinese cabbage research in developing a number of F₁ hybrids and open pollinated lines widely adapted to production under high temperature conditions in the humid tropics. The rapid acceptance of AVRDC lines and their release in Taiwan, the Philippines, Korea, and Japan has confirmed the value of these materials. Furthermore, the breeding approaches, as currently underway, together with those planned for the future, will ensure that over the next few years a supply of improved lines will continue to become available to national programs. It is with this perspective in mind that the Panel recommends that the direction of the Chinese cabbage program be carefully evaluated in the next year to examine the possibility of reducing the activities to a level that would still ensure that the progress made over the past is maintained for the future. If and when the activities in the Chinese cabbage program are being reduced, the Panel would recommend that activities on another crop, preferably with similar breeding characteristics and possibly related to Chinese cabbage, be considered for inclusion as a new mandate crop.

An example of such a crop would be the vegetable morphotypes of the mustard, Brassica juncea, which exist in leafy, large-rooted, loose-heading and thickened-stemmed forms. This is a highly nutritious vegetable which has undergone very little refinement through plant breeding.

B. juncea has the potential for fresh market use, pickling, and canning. Vegetable forms of B. juncea exist primarily in Taiwan and the Sechwan Province of China. The fact that B. juncea is an amphidiploid species containing as one of its pair of genomes that of B. campestris, makes it highly amenable to genetic improvement via the introgression of vegetable quality and adaptive characteristics from B. campestris subspecies such as Chinese cabbage. Cytoplasmic male sterility exists within B. juncea, making F₁ hybrid production a relatively straightforward task.

It is with this general recommendation in mind that the following specific assessments and recommendations of the existing Chinese cabbage program are made.

Germplasm Bank

The AVRDC Chinese cabbage germplasm collection has become recognized as an important world resource. The financial support of medium term storage equipment from
the IBPGR, together with the funds supporting characterization and multiplication of the collection, indicates the value placed on this important working collection by the international germplasm community.

Regardless of whether an active Chinese cabbage exists at AVRDC, the germplasm collection should be maintained as an active working collection in which characterization and new accessioning are adequately supported.

**Breeding Programs**

The breeding strategies currently used and projected for the future have good prospects of yielding steadily improving hybrids and open pollinated stocks. Based on the Panel's, suggestion to reduce inputs in the total program to a "maintenance level", the panel recommends that concentrated short-term efforts be made to produce more time-and-space-efficient disease screens so that these could later be used efficiently in maintaining improved stocks already in the program. Efforts in detecting insect resistance in Chinese cabbage might be more appropriately spent on the proposed integrated pest management activities. Likewise, efforts to determine the factors involved in flooding tolerance in Chinese cabbage might be more appropriately directed to a crop such as tomato, where soil saturation seems to be a major deterrent to plant growth. Stronger advocacy of the application of 30 cm bed heights in national programs which are testing AVRDC lines could result in higher performance ratings for the heat-tolerant materials in areas of high rainfall.

**International Testing**

It is essential that the Chinese cabbage program foster a vigorous international testing program for all of its improved lines by continuing to provide seed of advanced materials, together with the information necessary to optimize production. Timely seed increase of parental, hybrid, and open pollinated materials will be necessary at AVRDC to maintain an adequate supply of stock seed for distribution.

**Maintenance of Recommended Varieties and Seed Production**

It is in the area of seed supply maintenance and seed production of recommended varieties that the Chinese cabbage program risks not achieving its primary objective of ensuring a stable supply of its improved materials to farmers. Not until national programs are
capable of reliably producing seeds for their farmers or seed production agencies, either private or public, are able to serve as a reliable source of AVRDC materials, will the Chinese cabbage program be fully effective. The Panel believes that AVRDC must actively explore possible mechanisms and avenues for the reliable production of its superior Chinese cabbage lines. Furthermore, the program should continue to assist as fully as possible with both training and consultations for national programs desiring to develop Chinese cabbage seed production capabilities.

Pathology

Pathologists should continue to remain particularly alert to any changes in the expression of resistance in the AVRDC lines resulting from the origination of new virulent strains, and be prepared to respond to renewed breeding efforts that require identification of new sources of resistance.

Training

The Chinese cabbage program should continue to serve as a major source of research and crop management training as part of the AVRDC training program. Special initiatives in training in the area of seed production technology (as it relates to Chinese cabbage open pollinated and F1 hybrid seed) may have to be taken with national program personnel where AVRDC lines have been released as named varieties.

Communications

The Chinese cabbage program may wish to consider the development of the necessary technical information publications describing the attributes of the AVRDC Chinese cabbage lines, together with detailed information on cultivation practices that can be used to optimize production. A similar sort of document might also be developed to assist in the production of Chinese cabbage seed.
4.2 Tomato

4.2.1 Background and Objectives

Tomato is one of the most widely grown vegetables in the world. Since it is already well accepted in developing countries, it will become much more popular in those countries if production can be significantly increased.

As tomato suffers from heat (which reduces fruiting) and diseases when it is grown under high temperature and humidity, research at AVRDC emphasizes heat tolerance and resistance to diseases.

AVRDC screening efforts have led to the development of heat tolerant, and bacterial wilt-resistant cultivars. These materials, however, generally have small, soft fruits which crack when exposed to rain. The current emphasis of the tomato improvement program is to combine characteristics such as resistance to tomato mosaic virus (TMV), nematodes, and cracking, as well as improved fruit size, firmness, and color.

Long term objectives are to develop lines with:

(a) The ability to set fruit under mean temperature higher than 25°C;

(b) Resistance to common tropical diseases such as bacterial wilt, TMV, and nematodes, and, if possible, to less common diseases such as late blight and tomato leafcurl virus;

(c) Resistance or tolerance to pests; and

(d) Good fruit traits.

Processing tomato is one of most important cash crops in southern Taiwan. Tomato processing has also been initiated in Thailand, the Philippines, and Indonesia. Since TK-70, the most commonly grown cultivar in Taiwan, does not have heat tolerance and disease resistance, production has been limited to the cool, dry season. New cultivars that can be grown in hotter seasons and that can be harvested by machine are needed to reduce production costs. A special breeding program has been initiated to meet this demand.

4.2.2 Means and Facilities

The tomato group operates as an interdisciplinary team consisting of two breeders (one for fresh market tomato and
the other for processing tomato), two pathologists (one for fungal and bacterial diseases and the other for viruses), one entomologist, and one physiologist. Although each scientist has research assistant(s), each senior scientist is assigned to other crops as well. Including personnel outside of the tomato group, the total personnel resource input is 8.7 MY (man years), consisting of 3.0 MY for senior scientists and 5.7 MY for research assistants. The disciplinary inputs breakdown is as follows: Breeding 1.8 MY, Pathology 2.9 MY, Entomology 0.7 MY, Physiology 1.2 MY, Chemistry 0.3 MY, Crop Management 0.6 MY, Soils Science 0.2 MY, Soil Microbiology 0.2 MY, Germplasm/seed laboratory 0.4 MY, and Training 0.3 MY.

There is no serious shortage of plot space, although the program has lost valuable field experiments during the hot monsoon months due to excessive rainfall and flooding. Existing greenhouse facilities cannot be used during the hot season.

4.2.3 Achievements and Progress

Breeding

(a) A total of 5,350 accessions of L. esculentum and related species have been assembled in the germplasm collection.

(b) A few Philippines accessions have been identified as heat tolerant and/or bacterial wilt resistant, and these characteristics have been successfully incorporated into advanced breeding lines.

(c) Advanced lines have been distributed to many countries for adaptation trials. AVRDC outreach programs generate intensive collaboration between the Center and the host countries' national programs, and have resulted in release of at least 25 AVRDC tropical tomato lines to farmers in 17 countries. Many more lines are being used in national and private sector breeding programs.

(d) Genetic resources have been identified that are tolerant to heat, resistant to bacterial wilt, resistant to TMV and nematodes, and that have fruit characteristics such as improved firmness, larger size, better color, and cracking resistance. Some of these materials are being used in the breeding program to incorporate desirable characteristics into advanced lines.
(e) For the processing tomato program, sources of heat tolerance and resistance to TMV, nematodes, and bacterial wilt have been identified, and some of these lines are being used in the hybridization program; combinability tests for various traits are being conducted with elite parental cultivars and other sources of resistance: two cultivars will be released for paste production; promising large-fruited, nematode- and bacterial wilt-resistant cultivars are being developed; and introduced cultivars suitable for mechanical planting and harvesting are being tested by national programs in Taiwan.

Pathology

**Bacterial Wilt**

(a) Bacterial wilt resistant accessions were identified, as were a number of resistant breeding lines. These materials are being used in a number of countries overseas and in Taiwan.

(b) A field nursery with a high population of eight *P. solanacearum* isolates was established. All isolates were found to differ in their pathogenicity, complicating the breeding program.

**Tomato Mosaic Virus TMV**

(a) A survey made in Taiwan indicated that out of the 578 leaf samples tested, 39% were infected with TMV. Among the infected samples 57% contained TMV-0, 42% contained TMV-1, and the rest contained TMV-2.

(b) TMV-infected seed was found to contribute to the high incidence of TMV in tomato, and most commercially available tomato seed cultivars were found to be infected.

(c) Treating air-dried seeds (4-6% moisture) at 78°C for two days eliminated the seed-borne source of TMV without adversely affecting germination.

(d) Soil was found to be a vector for TMV.
(e) TMV infected soil may infect new plantings for five months following a tomato harvest.

(f) Flooding or crop rotation did not reduce TMV incidence.

(g) The use of seedlings raised in TMV-free soil reduced the infection of tomatoes planted in TMV-infected soil.

**Root Knot Nematode**

(a) A small number of nematode resistant advanced breeding lines were identified.

(b) Biological and chemical controls have proven promising and a synergistic effect between root knot nematode and bacterial wilt was identified.

**Late Blight**

(a) Breeding stocks have been selected for late blight resistance.

**Tomato Leafcurl Virus**

(a) The nature of the causal agent was described.

**Potato Virus-Y (PVY)**

(a) Several PVY isolates were isolated from tomato in Taiwan.

(b) Two sources of resistance were collected, and a survey for the presence of PVY in other Southeast Asian countries has been initiated.

**Cucumber Mosaic Virus (CMV)**

(a) A number of CMV isolates have been collected from tomato.

(b) There is evidence of the presence of several strains of CMV in the field.

(c) An inoculation technique for mass screening has been developed.
Other Fungal Diseases

(a) A number of tomato lines were identified as having resistance to grey leaf spot and powdery mildew.

Entomology

(a) Two accessions were found to be resistant to tomato fruitworm. This resistance is now being incorporated into high yielding cultivars.

(b) The use of reflective surface mulch and the covering of plants with fine nylon mesh screen was found to be effective in the control of aphids.

Physiology

(a) Poor fruit set at high temperatures, usually above 30°C, was found to be related to abnormalities which take place at various stages in the development of the reproductive organs. These phenomena account for differences in the reduction of fruit set and are variety dependent.

(b) All tomato germplasm accessions were screened in the field for high fruit setting ability; a few cultivars were identified as having acceptable fruit setting ability under high temperatures, and one accession was used as a source of heat tolerance in Taiwan.

(c) A few accessions were identified as tolerant to flooding; tolerance, however, was not equivalent to that of many other crops.

(d) Application of auxins (4-chlorophenoxy acetic acid and 8-naphthoxy acetic acid) on open flowers induced parthenocarpic fruit set and increased fruit yield under high temperatures.

Soil and Crop Management

(a) Thirty cm proved to be the optimum height for raised beds during the summer typhoon season.

(b) Two weedings between 28 and 42 days after transplanting were found to prevent significant yield loss from weeds, Metribuzin was found to be the best herbicide for transplanted tomato.
(c) Carbonized rice hulls, plus a nutrient solution, was identified as a good medium to produce healthy seedlings.

(d) A double-layer mulch consisting of rice straw and a silver-colored vinyl sheet decreased soil temperature by 2-3°C, and doubled the yield increase obtained from rice straw mulch treatment.

(e) Tomato plants grown on low beds were shown to need 180 kg/ha nitrogen and irrigation every 10 days, whereas those grown on a one-meter high bed with a vinyl roof produced almost the same yield with 30 kg/ha nitrogen and without irrigation for more than two months. This implies that nitrogen and water efficiency can be increased under high bed conditions due to good root growth.

**Economics**

Surveys made in Taiwan indicated that:

(a) Advantages listed by farmers for processing tomato were a guaranteed price and buyer, sale of the total harvest, technical guidance for cultivation, and healthy and vigorous seedlings.

(b) Yield of summer tomato in the highlands depended more on agronomic than economic factors, and that research should focus on the development of cultivars with superior resistance to rain damage, fruit cracking, pests, and high temperatures.

(c) Superior heat tolerant tomatoes should be developed for lowland areas so that farmers can earn higher prices by planting early.

(d) Fresh market, indeterminante varieties require a great deal of staking, pruning, and tying to obtain large, high quality fruit, but offer farmers a steady cash income over a long period. Determinant-type processing varieties were better adapted to the integrated farm-factory approach, but weaken the farmers' bargaining position.

**4.2.4 Future Research**

Future research will be aimed at improving diseases and insect resistance, heat tolerance, and fruit size and quality.
Breeding lines carrying desirable characteristics will be made available to national programs and/or government-nominated private sector breeding programs. These will include the parent inbred lines for those programs able to commercialize F₁ hybrids; advanced lines appropriate for use as improved cultivars will be made available to countries that do not have their own adaptive breeding programs.

Major research will emphasize:

(a) The combination of heat tolerance and resistance to bacterial wilt, TMV (two strains), nematodes, and other diseases.

(b) The incorporation of heat tolerance and bacterial wilt resistance into large fruited, fresh market, salad-type cultivars.

(c) The identification and utilization of better sources of resistance to early blight, late blight (for the highland tropics), and common viruses other than TMV (for the lowland tropics).

(d) The transfer of flooding tolerance to advanced tropical lines.

(e) The development of good combining processing-type parent lines with some levels of heat tolerance and resistance to major diseases.

In addition, the soil and crop management group will study:

(a) The use of a fluid seeding method which involves pregerminated seeds in a jelly-like medium that are drilled into the soil to reduce the adverse effects of transplanting.

(b) The development of methods to produce uniform and healthy seedlings.

(c) The application of plant hormones to increase fruit setting, etc.

4.2.5 Assessment and Recommendations

The Panel recognizes the achievements of the tomato group and its impact on tomato production in the tropics through the development of heat tolerant, bacterial wilt resistant materials and their transfer to national programs for use by farmers.
The Panel endorses the approach being taken by breeders to improve these materials by combining them with resistance to other diseases and insects, greater heat tolerance, and better fruit traits.

As processing tomatoes are expected to become more important in the tropics, the Panel supports the continuation of the processing tomato program within the limits imposed by financial and staffing constraints. To accelerate the program, the panel supports the proposal to obtain access to an experimental site in the highlands to permit experimentation during the hot, monsoon season. The site selected should be easily accessible.

There is room for improvement in the method of growing uniform, healthy seedlings for breeding purposes. The Panel feels that the crop management group may be able to contribute to this problem; the results may also prove useful to farmers.

While there are many tomato diseases, exact information on their occurrence and their relative importance in various locations in different seasons is still required. The panel recommends that such a survey be undertaken in the near future. Until the survey is completed, priorities for resistance breeding of less important diseases cannot be established.

Based on the progress made by the physiologist concerning the effect of high temperatures on fruit setting, the Panel recommends continuation of the study to improve the heat tolerance of existing cultivars.

Although some flooding tolerance in tomato seems to exist, that tolerance tends to be lower than in other crops. For the time being, it may be more efficient to try to solve this problem by means of improved crop management techniques, rather than by breeding.

As some problems are not expected to be solved in the near future, even after intense breeding efforts, research on crop management, including soil-water management and integrated pest management should be conducted more intensively to bridge the gap between environmental conditions and the capabilities of available cultivars. These problems are generally location specific, and, as such, emphasis should be placed on providing a basic understanding of the problem which can then be applied under a range of environmental conditions.
4.3 Sweet Potato

4.3.1 History and Background

Sweet potato (Ipomoea batatas), which was introduced from its original home in tropical America and the West Indies into Asia many centuries ago, has played, and continues to play, a major role as a source of food in Southeast Asia and the Pacific. It is estimated that more than 94% of the world's sweet potato (98.6 million tonnes) is produced in Asia and the Pacific Islands. In 1980, the crop was ranked fourth to rice, sugarcane, and wheat in terms of total food production in Asia. In mainland China, sweet potato is second only to rice and accounts for more than 80% of the world's total production.

The selection of sweet potato as an AVRDC mandate crop was in recognition of the fact that it had not received sufficient research attention with regard to improvement in yield and quality as a vegetable or food crop. Also, its potential contribution to nutrition and food for the poor especially in view of its richness in vitamin A and protein, had not been fully realized. Sweet potato can be easily grown the year round in the tropics on both fertile and marginal land. It also fits quite well into the multiple cropping systems common in tropical Asia. Sweet potato greens can be consumed as a vegetable.

Despite its importance, the area devoted to sweet potato production decreased by more than a million ha in Asia between 1970 and 1980, while average yields have remained virtually constant at 8 t/ha. However, great potential exists for using sweet potato as food, feed, and as a vegetable (green shoots), in Asia and in many other tropical regions. This fact provides the main justification for AVRDC's continued attention to sweet potato.

The initial goals of the AVRDC sweet potato improvement program were to develop adapted, high yielding, nutritious cultivars which could be grown under relatively low input conditions, and to develop management practices suited to tropical farming systems. Initial success was achieved with orange-fleshed, vitamin-rich, early-maturing cultivars which could be grown in cropping systems after rice as a main crop. Some attention has also been given to development of sweet potato as a vegetable crop (tips, leaves and petioles) for the supply of protein, vitamins, and minerals.

Production patterns in Asia and the Pacific indicate that sweet potato utilization changes as economic growth and human welfare improve; usually food use decreases, while feed and
industrial uses increase. This pattern is likely to run true for most developing countries. Therefore, the current emphasis at AVRDC on breeding and developing varieties with high dry matter, improved protein content, and high digestibility is considered appropriate. Sweet potato as an adapted subsistence crop is noted for having great potential for development as a major energy source, especially in view of the fact that AVRDC varieties can yield in the range of 20-46 t/ha over a 4-month period.

4.3.2 General Objectives

The overall objective of the sweet potato program is to develop widely adapted, stable and nutritious cultivars with pest and disease resistance, and low input requirements. In pursuit of this objective, physical, biological and nutritional factors, and the multipurpose utilization requirements of sweet potato are taken into consideration. This makes it necessary to focus on yield stability, environmental adaptability (including heat, drought, and flood tolerance), nutritional and organoleptic qualities, dry matter yield, pest and disease resistance, and suitability for use as leafy vegetables.

The general objectives are therefore pursued with inputs from breeding, pathology, entomology, physiology, and crop management.

Breeding

Breeding approaches sweet potato improvement through the development of widely adapted, stable yield cultivars with acceptable nutritional, feed, and industrial qualities derived from local and introduced genetic resources. In addition, efforts are made to develop tender-tipped, high-yielding types for use as vegetable greens. Although the emphasis has hitherto been on the development of cultivars, it is proposed to multiply and distribute AVRDC breeding materials to national programs as soon as safe and rapid methods of distributing vegetative materials are developed and/or expanded.

Pathology

Pathology's approach to the most prevalent disease problem on sweet potato (known to be caused by mycoplasma-like organisms and viruses) is to screen for stable disease resistance, or in the absence of such resistance, to develop practical control methods. This is of special importance in view of the fact that the viruses which cause the most serious diseases in sweet potato are most easily spread by the customary vegetative propagation.
Entomology

The sweet potato weevil (Cylas formicarius) and the stemborer (Omphisa anastomasa[s]), the two most important pests of sweet potato, cause serious losses in yield and quality. AVRDC's approach is to reduce or eliminate these losses through screening for pest resistance in the germplasm and through the development of pest management strategies. There is also a clear objective to incorporate the results of these approaches into the breeding strategy for pest and disease resistance.

Physiology

Physiology contributes to sweet potato development through studies on drought and flooding resistance and the physiology of flowering and seed setting (the latter is an important element in breeding and variety improvement). The development of improved meristem culture techniques and the maintenance of disease-free clones provide essential services that facilitate the distribution of germplasm for use in national programs.

Crop Management

The crop management unit's contributions are in the areas of crop rotation studies and soil and water management.

4.3.3 Structure and Procedures

The structure and procedures of the program are principally conditioned by the scientific disciplines that contribute to the major thrust of the program. Coordination in this particular case is provided by the sweet potato breeder who serves as the commodity group coordinator.

Breeding

The breeding program is aimed at maximizing genetic resources through the introduction of clones and true seeds from improved populations. Attention is being paid to the combination of essential characters required of sweet potatoes used for food, feed, and industrial purposes. The improvement of the nutritional and organoleptic qualities (with special reference to proteins, vitamins and texture) represent one focus, while improvement in protein, dry matter content, digestibility, and processing qualities represents the other. Efforts
are also being made to incorporate pest and disease resistance, and tolerance to certain environmental conditions. Attention has also been focused on the development of cultivars which yield large quantities of sweet potato tips.

Germplasm Collection, Maintenance, and Distribution

Sweet potato breeding was initiated at AVRDC in 1973, and to date a total of 1,300 accessions have been collected from all parts of the world. Most accessions have been characterized using IBPGR descriptors, and have been evaluated for pest and disease resistance or environmental tolerance. The IBPGR recently designated AVRDC as the official repository for sweet potato germplasm in Asia. Construction of new facilities, including seed laboratories, better storage facilities, tissue-culture rooms and a post-entry screenhouse is underway, and this should greatly facilitate the maintenance and distribution of sweet potato germplasm. The expansion of the distribution of AVRDC elite germplasm to national programs as disease-free meristem cultures will have the advantage not only of producing early releases but will strengthen many national breeding programs in advancing their programs using materials supplied by AVRDC.

Breeding and Screening Techniques

Sweet potato breeding has been advanced through the successful use of free-flowering cultivar 172 as root stock to induce flowering. Major cross-incompatible groups have been identified, and the information has been used to produce large quantities of seeds for cross combinations. With the establishment of outcrossing populations for high protein, low sugar, and desirable plant types, it should be possible to make rapid progress in developing materials adapted to regional production environments.

The development of rapid field screening techniques for selecting high dry matter and high protein clones in the seedling stage has permitted the screening of more than 50,000 genotypes a year in order to identify lines of interest for the different requirements of food, feed, and greens. Because of their heterozygosity and high ploidy level, selection can be started with F1 plants, and selected genotypes can be subsequently evaluated for adaptation and then maintained asexually.
Improvement of Nutritional Quality

AVRDC’s initial thrust in sweet potato improvement was to develop high yielding and nutritious selections. Most of the elite lines developed are orange-fleshed, rich in vitamin A, and early maturing (100-120 days). As a result of these characteristics they are well suited to Asia’s rice-based cropping systems.

Recent progress has been made in developing lines with over 9 mg of carotene/100 gram, greater than 7% protein, the preferred dry texture characteristics, and 28% dry matter. Dry matter yields of 13 t/ha have been reported. Selections are first based on flesh color (β-carotene content), protein, and dry matter content. Subsequently determinations are then made on the basis of yield stability, root size, shape and eating quality.

Adaptability

Adaptability to environmental and biological stress has been approached with a focus on high yields under hot-wet environments, low input conditions, and drought and flooding. These studies have resulted in the identification of selection CN 1028-15 which has produced up to 40 t/ha in Taiwan, 50 t/ha in Tahiti. Other breeding lines and accessions have also shown the capability of producing yields of up to 25 t/ha under low input conditions.

Vegetable Sweet Potato

The screening of accessions and development of breeding lines for vegetable type sweet potato have led to the identification of bush-type clones with superior eating qualities and yields of 15-16 t/ha of edible tips. A yellow-leafed line has also proved to have suitable flavor and tenderness.

Animal Feed and Industrial Sweet Potato

It has been demonstrated that sweet potato has a better chance than most grain crops to be developed as a major energy source. Cultivars at AVRDC yield up to 46 t/ha (13 tons of dry matter) which is more than triple the yield of most local cultivars. Cultivars and accessions which exhibit lower trypsin inhibitor activity and better starch digestibility have also been identified, making it possible to develop cultivars which do not require cooking prior to use as animal feed. Further, high yielding
industrial or feed type sweet potatoes which are low in sugar will be crossed with high protein accessions to obtain initial populations for selection. The initial emphasis of this project is on yield potential and protein content; later selections will address taste, shape, and other traits.

**Pathology**

The objectives of AVRDC's sweet potato pathology program is to identify sources of resistance to the disease caused by mycoplasma-like organisms (MLO) and viruses. These pathogens, which have been widely reported in Southeast Asia, are easily transferred to successive generations through vegetative propagation. Where resistance is not available attempts have been made to develop practical control methods.

MLO resistance genes have been identified in one accession and incorporated into AVRDC breeding lines even while screening continues. In order to render AVRDC germplasm virus-free, meristem culture techniques, supported by a vigorous program of virus indexing of clones, have been developed in collaboration with the breeding and physiology programs. More reliable methods for the identification and detection of viruses are being developed, and surveys of viruses in Southeast Asia will be continued.

**Entomology**

Two major pests of sweet potato, sweet potato weevil (C. formicarius) and stemborer (Omphisa anastomalis), cause substantial losses in yield and quality. The strategy of the entomology unit is to reduce those losses through the identification and breeding of weevil and borer resistant lines, and through the development of integrated pest management, including the study of insect-plant interactions.

Only two accessions have been found to be moderately resistant to the weevil and stemborer. Pre-plant dipping of cuttings in 0.05 to 0.1% carbofuran solution or 3-weekly applications of 2 kg/ha carbofuran were found to be effective, though the latter method proved uneconomical due to the large amount of chemical used. The development of integrated pest management methods will receive greater emphasis in the future with a view to providing a reliable control method that can be adopted by small-scale sweet potato producers in Southeast Asia.
**Physiology**

The focus of the physiology unit's sweet potato research is to provide a better understanding of the flowering and seed set processes. In addition, emphasis is directed to providing input on drought and flood resistance or tolerance that can be incorporated in AVRDC breeding lines. Physiology also assists in the development of meristem-culture techniques for the maintenance and distribution of virus-free materials.

Some progress has been made in the identification of drought and flood tolerant lines with high dry matter yields, but more work needs to be done. Studies on the pattern of photosynthate partition and the source and sink relationships of leaves, stems, and storage roots are likely to assist in improving the yield potential of sweet potato.

**Cooperative Programs**

The cooperative or outreach programs on sweet potato cover the major producing countries in Southeast Asia (Taiwan, Thailand, Philippines, Indonesia, Korea) and in the South Pacific. Increasing numbers of AVRDC materials have also been made available to national and international programs in Africa, Central America, and the Caribbean. The major limitation continues to be a lack of facilities at AVRDC for developing and distributing virus-free materials in the form of meristem cultures. A recent survey of sweet potato production and utilization in the region has produced updated information on the current status of production and utilization, constraints, and future trends. The results of the survey have been used in advisory meetings and discussions aimed at strengthening the activities and focus of AVRDC sweet potato research.

Plans are being made to evaluate AVRDC elite breeding lines in bilateral programs in Thailand, Korea, Indonesia and the Philippines, and to establish germplasm pools for use by national programs in each of these countries.

The ultimate aim, however, is to establish an International Testing Nursery which will regularly screen new materials for yield, adaptability, pest and disease resistance, and consumer acceptability. Work will also be done on the identification of viruses, antisera production, and the screening of the germplasm for resistance to major pests.
Staff, Facilities, and Budget

Program staff consist of five senior researchers: One breeder, two plant pathologists, one entomologist, and one physiologist. All senior staff members have responsibilities in at least one other mandate crop. An estimate for staff time allocated to the crop calls for only 2.4 man years. This includes support at varying levels by such units as biochemistry, nutrition, anthropology, crop management, soil science, statistics, seed technology, and training. Two Principal Research Assistants and three research assistants provide additional scientific and technical expertise.

Very limited assistance is provided for the outreach or cooperative programs. The core staff, therefore, are largely involved in initiating and monitoring outreach work.

The US$11,934 provided in the 1983 budget (excluding staff remuneration) appears to have been sufficient for the scientific research effort devoted to sweet potato. The comparative figure for 1984 is about US$12,000 which is about 19.9% of the total budget of $60,414 for the operating expenses of the entire Horticultural Crops Program.

Accomplishments

Objectives have been largely achieved through the development of orange-fleshed elite lines which are rich in vitamin A (4-12 mg/100 g of fresh wt. of B-carotene) and are early maturing (100-120 days). The characteristics of early maturity and low input requirement should permit the use of AVRDC lines after rice without extensive soil preparation, irrigation, or other costly inputs, and could bring into production part of the 39 million ha of idle rain-fed rice fields in Asia alone. The major emphasis of the sweet potato breeding program and the status and relevance of current approaches are summarized by AVRDC in the following table.
### Table 1. Major Emphasis of AVRDC's Sweet Potato Breeding Program

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Development level&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>High and stable yield</td>
<td>2, 3</td>
</tr>
<tr>
<td>Improved eating quality and nutrition</td>
<td>2, 3</td>
</tr>
<tr>
<td>Resistance to sweet potato weevil</td>
<td>4</td>
</tr>
<tr>
<td>Resistance to virus</td>
<td>5, 6</td>
</tr>
<tr>
<td>Resistance to witches' broom</td>
<td>2</td>
</tr>
<tr>
<td>Tolerance to drought</td>
<td>5, 6</td>
</tr>
<tr>
<td>Tolerance to flooding</td>
<td>2, 4, 6</td>
</tr>
<tr>
<td>Wide adaptability</td>
<td>2, 3</td>
</tr>
<tr>
<td>Resistance to stem borer</td>
<td>2</td>
</tr>
<tr>
<td>Resistance to scab</td>
<td>4</td>
</tr>
</tbody>
</table>

<sup>a</sup> 1. Genetic resources successfully incorporated into the majority of advanced lines. Impact made in national programs due to the improvement of these characteristics.
2. Genetic resources being used in breeding programs for combination with other desirable characteristics.
3. Genetic resources identified that are equal to or better than local cultivars. An improvement program is ongoing.
4. Identification of genetic resources required.
5. Developing and/or improving screening and selection methodologies.
6. Conducting basic research to strengthen the program.

It can be seen that "development level 1" (genetic resources successfully incorporated into the majority of advanced lines and impact made in national programs due to the improvement of these characteristics) is yet to be attained; this is largely due to the constraint of transfer of disease-free materials to national programs. However, sufficient progress has been made in level 2 to indicate that advanced lines with a combination of desired characteristics will soon be widely available to national programs.

Specific accomplishments have been made in respect to yield, nutritional quality, disease resistance, weevil control, and meristem culture development. Some of these accomplishments include:
(a) The release of AVRDC accessions by the national program in the Philippines

(b) The development of orange-fleshed dessert lines that yield 20-35 t/ha, are high in β-carotene (4-12 mg/100 g fresh weight), and mature in only 120 days.

(c) Cultivars with high Vitamin A content, preferred dry-texture and high dry matter content (26%).

(d) The establishment of different improved sub-populations (low-sugar, high protein, bush-type, and weevil resistant) as gene pools for long-term variety improvement programs at AVRDC and national programs.

(e) Identification and transference of MLO (witches' broom) resistance to promising breeding lines.

(f) Identification of elite breeding lines that provide consistent yields of 20 t/ha (dessert, staple, and feed types) for the hot-wet season.

(g) Progress in the development of an integrated weevil control program involving low cost insecticide and weed control.

(h) Development of a meristem culture system for vegetative reproduction.

4.3.6 Constraints and Future Plans

The major constraint in the program is the inadequacy of facilities for the rapid propagation and distribution of disease-free meristem cultures. The Panel was informed that plans are being made to provide additional facilities and a quarantine glasshouse to facilitate the production and distribution of AVRDC selections to national programs.

A second important constraint is in the allocation of senior staff time, especially in respect to Entomology (0.2 MY) (man years), Pathology (0.3 MY), and Physiology (0.3 MY). A total of 2.4 MY of senior staff time and 2.4 MY for research assistants (including Germplasm and Training) cannot be considered an adequate critical mass for dealing with the improvement, pest and disease management, and production technologies of sweet potato research as indicated in AVRDC's overall objectives for the crop.

The Panel recommends that AVRDC Management should undertake a review of stated program objectives with a view to applying more rigorous priorities in determining what can be
done with the present resources if additional resources cannot be made available. In any case, the Panel recommends that an overall review of sweet potato research be undertaken within the next four years to determine appropriate levels of research inputs for this crop. Such a review should take account of any changes in the status of the crop and how successful AVRDC has been in overcoming problems of distribution of its improved materials.

The constraint of virus incidence on the distribution of materials from AVRDC could be removed by the development of more rapid and accurate virus indexing methods to ensure the delivery of virus-free breeding materials to national programs.

In recognition of the evolving status of sweet potato and the requirements of the countries served by AVRDC, it is proposed that future plans concentrate on the development of lines with high dry matter for animal feed and industrial uses, dessert types high in β-carotene and protein, and high-starch types acceptable for use as a staple food. The development of lines to fit ecological environments (such as drought- or flood-prone areas) and other cropping systems should also receive attention. Pest and disease resistance should be introduced into breeding lines and cultivars, as far as is feasible, or pest/disease management strategies developed which are compatible with the production systems.

Major projects for future research have been summarized as follows:

(a) Develop widely acceptable, stable yielding cultivars with low input requirements, drought tolerance, and adaptability to hot wet environments.

(b) Develop breeding lines resistant to sweet potato weevil, stem borer, scab disease and virus.

(c) Improve the nutritional content, quality, and palatability of existing lines (e.g. dry texture, better taste, higher β-carotene and protein and low fiber content).

(d) Develop lines with superior dry matter content.

(e) Develop tender, high yielding bush or semi-bush types for vegetable greens.

(f) Develop a safe, rapid virus-free method for multiplying breeding materials for the delivery to and testing of AVRDC breeding lines in national programs.
(g) Facilitate the flow of genetic resources to national and international programs.

(h) Organize an international network to test AVRDC sweet potato breeding lines.

(i) Establish outcrossing populations at AVRDC for specific types of genetic materials to be used by national programs.

It is clear that these plans will require additional resources if they are to have the desired impact in the next 3 to 5 years.

4.3.7 Assessment and Recommendations

The sweet potato program has been operating more or less in its present modest state since 1973, yet it has made substantial progress in developing high yielding, nutritious selections adapted to the low input cropping systems of tropical Asia. Most AVRDC elite lines are orange-fleshed, rich in vitamin A, early maturing, and have the potential to produce yields ranging from 20 to 40 t/ha. AVRDC accessions have been released in the Philippines, and AVRDC-selected disease-resistant materials have found their way into other national programs.

In spite of these successes, the average yields of sweet potato grown in the region remain low, representing only one-third or one-fifth of potential yield. Survey figures also indicate that production hectarage has also declined.

The Panel recognizes that the major constraint in the introduction of improved AVRDC materials to national programs has been the difficulty of processing virus-free material for wide distribution. In view of the fact that sweet potato is largely vegetatively propagated, the application of meristem culture methods, coupled with careful virus indexing, has to be adopted before reliable disease-free distribution can be guaranteed.

The Panel recommends that priority attention be given to the application of techniques for meristem culturing and virus indexing, and to the early movement of both cultivars and lines to variety improvement programs.

AVRDC has recognized the changing status and needs of Southeast Asian agriculture, and survey results indicate that sweet potato is likely to play three different roles in the future. It has therefore proposed in its five-year plan to devote attention to types that are suitable to food, dessert, feed, and industrial uses. The development of these lines for various production environments and systems in various
regions of the tropics may well reverse the declining trends now characteristic of sweet potato production and open up increased utilization channels. It should be pointed out that the increased research and development efforts that would be involved will need additional human and material resources.

The Panel recommends a review of the overall needs of the program so that the desired impact of bridging the gap between AVRDC's achievements and national programs' production performance can be achieved within the available resources. If additional resources become available, AVRDC should stimulate the rapid attainment of its objectives through the strengthening of sweet potato research.

The constraint on the distribution of materials from AVRDC should be removed as quickly as possible. In order to achieve this, the panel recommends that AVRDC collaborate with other international agencies and research centers such as the IBPGR, the South Pacific Commission, the Glasshouse Crops Research and Experimental Station (Holland), and the National Vegetables Research Station (UK) in establishing an internationally acceptable virus indexing system, and in training national program personnel in participating countries with a view to creating an international testing network for sweet potato. It is suggested that one way of achieving this is for AVRDC to seek the necessary funding from donor sources to launch this effort, thereby facilitating more effective utilization of its improved and promising cultivars in the countries that have shown interest in sweet potato research and development.
5. NUTRITION, ENVIRONMENT AND MANAGEMENT

5.1 General

The NEM program is aimed at gaining a better understanding of crop-environment interactions so that genetically improved varieties can be fully utilized. The disciplines presently included in this program are: Chemistry, soil science, economics, food nutrition/anthropology, crop management, and soil microbiology.

AVRDC lists the objectives for the NEM program as:

(a) Expanding the potential for production and utilization of vegetables and legumes in the tropics by providing a better understanding of crop and environment interactions.

(b) Improving the nutritional status of low-income farm families in the tropics through the introduction and promotion of more nutritious vegetables and legumes.

(c) Improving the economic status of small farmers in the tropics through the study and improvement of the socio-economics of farming and family living systems.

5.1.2 Activities

Staff in the NEM program normally collaborate with other scientists in research activities - either within the NEM program itself, or in the commodity, training, or outreach programs.

Research activities include: Cultural practices for AVRDC crops; herbicide evaluation and weed control; application of improved technology for production and management of nitrogen fixing organisms under tropical conditions; soil management technologies for tropical environments; intensive vegetable production farming systems; backyard home gardens; quality assessment and improvement of AVRDC crops; promotion of vegetable consumption in the tropics through appropriate processing; and prevention of vitamin A deficiency.

5.1.3 Staff

The NEM program includes 5 principal staff, 34 regular staff, and 21 laborers. The allocation of time of NEM principal staff is shown on the following page.
Allocation of Time of NEM Principal Staff.

<table>
<thead>
<tr>
<th></th>
<th>Legume Program</th>
<th>Hort. Crops Program</th>
<th>Vegetable garden</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soybean</td>
<td>Mungbean</td>
<td>Tomato</td>
</tr>
<tr>
<td>Chemistry</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Crop Management</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Soil Science</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Nutrition</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Soil Microbiology</td>
<td>0.5</td>
<td>-</td>
<td>0.1</td>
</tr>
</tbody>
</table>

* Number of man years per annum

5.1.4 Constraints

NEM scientists have listed the following constraints as affecting their activities:

(a) Crop and social environments are usually location specific. Information obtained at AVRDC is not universally applicable without modification.

(b) Inadequate coverage by background studies or surveys identifying constraints on the improvement of vegetable production and consumption in targeted areas.

(c) Few cooperators have been identified in targeted countries who are interested in conducting international trials for vegetable management technologies.

(d) Nutrition improvement programs in developing countries are often coordinated by medical doctors who concentrate on administering vitamin supplements, and overlook the potential of vegetables.
(e) In most developing countries few scientists work with vegetables.

5.1.5 Future Plans

Planned research activities of the NEM program include: Quality assessment and improvement of AVRDC crops; prevention of vitamin A deficiency; home, school, market, and processing gardens; soil and crop management technologies for tropical environments; pest control; and postharvest technology.

5.1.6 Assessment and Recommendations

The Panel recognizes that a high proportion of NEM staff time is, and should be, allocated to working directly with scientists in the commodity programs. As mentioned previously, much of the work, particularly of the crop management and soil science groups, has been assessed under commodity headings in this report. The work of other NEM staff is assessed under their disciplines.

The Panel was favorably impressed with the contributions of the NEM staff. The title of the program adequately describes its activities, and there is good cooperation between its staff and the staff of other programs in solving specific problems.

The NEM program addresses, in part, the difficult task of tackling problems that involve more than one commodity. The Panel rejected the possibility of including all NEM activities under the commodity programs since this would not simplify research management. In particular, it was agreed that development and testing of the technology to accompany improved AVRDC crop varieties would often involve, for example, considering the management implication of growing different crops in various sequences and special combinations. The Panel agreed that it was preferable to deal with multi-disciplinary research on multi-crop problems under a separate program.

However, the Panel also agreed that it did not feel comfortable with the difficulties of coordinating or even directing the disparate elements in the NEM program, which appears to have come into existence primarily for administrative convenience. The Panel agreed that the NEM program was being asked to cover too many activities over a wide range of specialties which gave the impression that the program lacked cohesion and direction with respect to its general objectives and activities. After lengthy deliberations the
Panel decided to recommend that AVRDC consider the establishment of a unit with the suggested title of "Central Resources and Services Unit" and that the existing program be re-named the "Production Systems Program."

The Central Resources and Services Unit would include Statistical and Computer Services, Chemical Analysis (including biochemical, soil and pesticide analysis), and the Germplasm Resources and Seed Laboratory.


A diagram of the suggested new relationships between these activities is included in the section on Research Management.

The Panel felt that there was room for more cooperation between individual scientists working on related problems outside of the individual crop programs. The Panel suggests that the Production Systems Program be given clear objectives with respect to both its roles in commodity-specific research and in multi-crop, multi-disciplinary work associated with the development and testing of new AVRDC technology, both on the research station and in cooperation with national programs through the outreach system. In this last respect, the Panel recommends that on-station activities be seen as a major responsibility of the Production Systems Program, and that off-station, on-farm activities be carried out through the outreach Program, and usually in the first instance, through the Taiwan Cooperative Program. The world "development" would then be removed from the "Training and Development" part of AVRDC's organizational chart.

The Panel devoted some time to the concepts of farming systems versus cropping systems research. In general, it was agreed that much of the responsibility for the on-farm testing component of farming systems research should be left to national programs where possible. The Panel therefore preferred the use of the term "cropping systems" which is regarded as a component of farming systems research, as commonly interpreted at other IARCs.

5.2 Soil Science

The soil science position has for a number of years been directly funded by the Government of Japan and filled by a Japanese scientist on a rotational basis. The crop-oriented studies in soils that the Panel considered when studying the
progress of the individual crops programs, involved such things as the best bed height (30 cm) for raised beds for tomato culture in locations prone to flooding, and studies on the nature of the problems encountered in mungbean/mungbean cropping systems. In addition, the soil science program reported on certain more general, less crop specific studies. Some of these studies are reported on the following page.

5.2.1 Accomplishments

In poorly drained soils, raised beds with a middle furrow in which rice hulls were buried acted as an efficient and rapid drain, although its life-span was restricted to approximately one crop season, i.e. 90 days.

Carbonized rice hulls were shown to be an excellent seedling medium for vegetables before transplanting. The conclusion to be drawn is that field soil contains many pathogens attacking seedlings.

A comparison of high beds (1m), as opposed to lower beds, demonstrated the tremendous effect of increasing the root zone or the volume of soil exploited by the plant. High beds produced high yield with a minimum of nitrogen fertilizer and very significant savings in irrigation water. The technique may or may not be economically justified, but it demonstrates the problems posed by hard pans restricting root growth and by high water tables.

Interesting results were reported with respect to leaf-tip burn in Chinese cabbage, which was diagnosed as being due to nutrient imbalance in the plant with ammonium (NH₄⁺) concentrations too high and calcium (Ca++) too low. The remedy suggested was to substitute nitrate fertilizers for the ammonium sulphate normally used on young plants.

A pot experiment with Rhizobium inoculated versus uninoculated soybean demonstrated the effect of nitrogen fertilizer in depressing Rhizobium efficiency, and also demonstrated that under the greenhouse conditions Rhizobium was able to fix nitrogen equivalent to 120 kg/ha, enough for a crop of about 1.3 t/ha of soybean.

Some interesting work was reported on a study which attempted to characterize the significant aspects of the ion absorption systems active in clay and organic matter in soils, with the ambition of devising a relatively simple test or series of tests to permit classification of soils into a relatively small and uniform number of groups with regard to phosphate fixing power and availability. The study will be a
long term one, but, if successful, will be extremely useful for all forms of crop culture.

5.2.2 Assessment and Recommendations

In analysing the functions and/or potential contributions of soil science to the AVRDC program, the discussion among Panel members indicated that two kinds of contributions were being made. One concerned the management of the soils of the experimental plots, with their drainage difficulties etc. The others were more general studies which are of basic interest to agriculture everywhere, and are not limited to the use of soils as media for vegetable production.

With regard to the first function, the Panel was satisfied that a major contributions to soil management on the experimental plots at AVRDC had been made and that the remaining problems were not in the sphere of soil science, but rather in drainage engineering and flood water control originating outside of AVRDC.

With regard to the basic studies in soil science, the Panel members felt that although such research is potentially very important, it is not specifically directed at vegetable production.

It would appear that for vegetable production, soil fertility practices, soil management, cropping systems, rotations, and those aspects of production normally considered to be associated with soil science are all highly location specific.

While the remaining problems of managing and using the AVRDC plots would seem not to lie with soil science (with the exception of soil analysis as a guide for fertilizer usage), it would appear that in the future, soil science research at AVRDC would steadily move to basic soil science studies which are not aimed directly at solving vegetable production problems.

If this analysis has any validity, it is suggested that a study group composed of representatives of disciplines associated with soil science look at the appropriate role of soil science at AVRDC. In the extreme case, it can be argued that NPK analysis of soils for fertilizer recommendations can be done in the laboratory by technicians, and that occasional problems such as tip-burn of Chinese cabbage can be tackled by the plant physiologist. In any case, the question should be reduced to a definition of what problems the soil scientist should address.

If the conclusion is that most of the immediate problems with the AVRDC farm that are amenable to treatment have been
dealt with, and that most of the cultural practice work has to be "fine-tuned" for location specific requirements, the question would remain as to how AVRDC would provide for its needs with respect to plant nutrition and of predicting problems suspected to be related to soil properties. It is possible that such problems could be dealt with by a soils agronomist for instance, i.e. a specialist with soils knowledge who has concentrated on the sciences associated with optimal plant production, who could perhaps be associated with the crop management group.

5.3

Crop Management

This area of research concentrates on synthesizing the package of cultural practices for high-yielding varieties.

As has been indicated in the Soil Science section, many of the individual management practices which make up a package of improved practices are location specific, and, almost without exception, the major elements of the package must be "fine-tuned" under the conditions prevailing where the crop is grown. Having said that, it remains the responsibility of the Crop Management group to:

(a) Demonstrate that a package can be put together which will establish the yield potential of the cultivar.

(b) Identify the important elements of the package of cultural practices so that these elements can be defined again under the local conditions in the country, region, or district in which the new technology is being tested.

The elements of such a package for vegetables may include seedling nursery sanitation, cultivation practices (including raised beds if necessary for protection against flooding), fertilizer amendments depending on local nutrient deficiencies, planting density, row spacing and spacing in the row, weed control (the critical period for control measures, whether by hand weeding or herbicides), herbicide effectiveness and rates of application, pest control by cultural or chemical methods for both diseases and/or insects, and post harvest care (whether for storage or processing).

AVRDC has a problem in that while a package can be developed for the areas in Taiwan, to do so in other countries requires liaison with local specialists. Unfortunately, the financial constraints under which AVRDC currently operates, whether at its headquarters or at the outreach programs, are sufficiently serious to prevent adequate involvement in the crop management aspects of the overseas programs. The panel considers that the initiation of an improved support
program for crop management in the development of appropriate packages of cultural practices for outreach programs is a very important part of the technology transfer process, and should be accorded some priority when additional resources are available.

5.4 Agricultural Economics

5.4.1 Background

AVRDC documents indicate that agricultural economics was originally designed as a service department to support the Center's crop improvement programs. Its primary objective is to identify the socio-economic constraints to increased utilization of improved vegetable technology in the tropics, and thereby help scientists to improve the focus of their research. The nature of this principle is reflected in the scope of work carried out during the past ten years. In the initial stage of the program, emphasis was given to existing production patterns of AVRDC crops. In subsequent years, marketing systems received attention. In recent years, some assessments of AVRDC-developed technologies were conducted.

Due to budget constraints, AVRDC's economics research activities are mainly concentrated in Taiwan. Although Taiwan is agriculturally more advanced than most of tropical Asia, AVRDC believes that the information and experience gathered there is still valuable because Taiwan's agriculture today can serve as a model for tomorrow's agriculture in developing countries.

5.4.2 Objectives

AVRDC economists aim to: Provide a better understanding of the socio-economics of tropical farming; describe current vegetable production patterns; describe vegetable marketing systems; develop methodologies for constraint surveys; and conduct analyses of constraints that interfere with the adoption of AVRDC technologies.

5.4.3 Staff

The agricultural economics staff consist of a research assistant, two junior staff, and a part-time consultant based at the National Taiwan University in Taipei. A principal staff position is currently vacant.

5.4.4 Achievements

AVRDC economists have achieved results in four main areas, largely based on research conducted in Taiwan:
(a) The provision of a better understanding of the socio-economic constraints to tropical vegetable production and to the adoption of new varieties and technologies.

(b) The assessment of efficient vegetable marketing infrastructures in Taiwan and their usefulness in providing models for other countries.

(c) The development of methodologies for dealing with farmers' attitudes to the risks associated with the adoption of new technology.

(d) Economic evaluation of the potential of management technologies proposed for AVRDC soybean cultivars and nutrition gardens.

5.4.5 Constraints

The major constraints of the economics group are the lack of senior leadership and the lack of travel funds for conducting research in other countries.

5.4.6 Assessment and Recommendations

The agricultural economics group has made a valuable contribution to the AVRDC program within the limits set by its budget. However, the Panel felt that there was scope for tightening its objectives.

The objectives of the economists must be set in relation to the realities of their budget allocation. The present allocation, even with the acquisition of a principal economist, does not provide the group with a critical mass in terms of conducting a substantial research program. In other words, without greater resources, the group will continue to serve largely in a service capacity in a technologically predominant research center.

In assuming a service/research role, the economist's main objectives should include:

(a) Assisting scientists to foresee possible constraints to the adoption of AVRDC technology.

(b) Assisting scientists in understanding why technology was not adopted or only slowly adopted.

(c) Assisting national programs in improving rates of adoption.
(d) Assisting AVRDC research management in making overall assessments of the impact of AVRDC programs and evaluating alternative research strategies.

It is clear that AVRDC economists have performed many of the service and research activities implied above. However, the work has been somewhat piecemeal and repetitive. Given the limited resources available, the economists could have placed greater emphasis on methodology rather than, for example, on descriptive surveys which should probably be regarded as the responsibility of the national programs. A desk-top study of IARC methodologies in constraint surveys and their adaptation to vegetable cropping systems appears warranted.

In a sense, the economists should see one of their roles as providing additional screening criteria for the plant breeders.

The Panel is not satisfied that adequate leadership can be provided to the program via the services of a part-time consultant. The consultant is able to visit the Center only occasionally, and it was clear in discussion with local staff that this arrangement is unsatisfactory. The Panel recommends that high priority be given to making a senior appointment in the economic sub-disciplines most directly concerned with identifying and dealing with constraints to producer and consumer acceptance of new technologies and their products, namely production economics and marketing. The appointee should be able to communicate with a wide spectrum of scientists, including the biologists at AVRDC and policy economists at institutions like IFPRI.

It should be admitted that the goals of AVRDC cannot be fully attained by biological research in the absence of a strong social science input on impact and constraints. There is a long-term need to answer questions such as who is benefitting from AVRDC research and where - "small" farmers, "large" farmers or both? Are the benefits accruing to local producers and consumers, or are they transferred to consumers in developed economies? Is research on some commodities and cropping systems likely to lead to inequit­able distributions of benefits and costs in countries which lack welfare programs? The Panel believes that in the long-term, AVRDC should have the capacity to participate in such research and recommends that AVRDC attempt to develop the research capabilities of the social science group within the scope of its available funding.
5.5 Chemistry/Nutrition

5.5.1 Background and Objectives

Deficiencies of nutrients such as vitamin A, iron, and calcium are the most important dietary problems in developing countries. Consumption of leafy vegetables and fruits can alleviate some of these problems.

The objectives of the chemistry group are: To improve the nutritional quality of the AVRDC mandate crops by collaborating with plant breeders, to develop appropriate technology to handle or process vegetables for the benefit of consumers, and to generate more income for farmers.

To accomplish these goals, the development of quick, convenient, and reliable analytical methods has been one of the major efforts of the group.

5.5.2 Means and Facilities

The chemistry group consists of one nutrition chemist, who is the Program Leader of the Nutrition, Environment, and Management Program, and two principal research assistants. Laboratory space and equipment appear to be adequate. The group has a cooperative research project with the University of Rhode Island on provitamin A analysis.

5.5.3 Research Progress

It has been demonstrated that the present AOAC method overestimates provitamin A by 30-50% in most plant materials. A modified method has been proposed for food commodities which have wide differences in their carotenoid patterns. A rapid mass screening technique has been developed to determine the β-carotene content of sweet potato.

For processing tomatoes, a quality standard for pH, solids, titratable acids, and color was established for variety evaluation.

Sweet potato varieties were classified into four types: Staple food, snack food, feed, and starch. For the staple food type protein content of 6 to 7%, sugar content of 3 to 5%, and high dry matter content are preferable; for the snack food type, high β-carotene content is the most suitable. For the feed type, high dry matter and protein content are desirable. AVRDC germplasm has been screened for high dry matter, high protein, and low sugar content.

Sweet potato is low in its digestibility as a feed due to trypsin inhibitors and starch characteristics. Both of these
factors can be improved by cooking. A positive correlation has been shown between protein content and trypsin inhibitor activity. The inhibitors are fairly heat stable, and about 80% of their activity is maintained even in sun-dried chips.

The nutrient value of mungbean protein is relatively poor because of its low methionine content. Germplasm screening indicates that there is no high methionine line in the AVRDC mungbean collection. Blackgram, however, has a high methionine content. Based on this information, an interspecific crossing program has been initiated.

Based on dietary patterns and food prices at a given location, a "relative nutrient cost" system was developed for estimating the overall nutritive value of food commodities. This value varies from place to place, depending on food pattern, price, and nutrient content.

An air classification process has been developed for separating mungbean starch and protein, as indicated in the section on mungbean.

5.5.4 Strategy and Future Plans

The chemistry group will continue to work towards the dual goals of developing varieties with better quality and improving the utilization of the crop products, rather than evolving toward detailed nutritional chemistry. More emphasis will be given to the following areas: Improvement of the provitamin A assay method and subsequent assessments of various food commodities; screening of tomato germplasm or lines for high yield, high solids content, and good color under high temperature regimes; screening of sweet potato lines for starch characteristics that do not affect protein digestibility and for french fry suitability after identifying the effects of sugar, free amino acids, starch properties and moisture content; the identification of flatulence-causing substances in sweet potato roots, the development of assay techniques for flatulence, and screening for low flatulence materials; improvement of mungbean protein quality through interspecific hybridization with blackgram; the development of processed sweet potato products by extrusion cooking in which trypsin inhibitors are destroyed and starch is gelatinized.

5.5.5 Assessment and Recommendations

The activities of the chemistry group consist of identifying nutritionally beneficial vegetable traits for which screening is justified, and the development of assay and screening
methods. In each of these areas, the group has made considerable progress.

Although the development of assay methods is the responsibility of the chemistry group alone, other activities can be achieved only by cooperation and agreement on objectives between breeders and chemists. The panel recognizes that there has been good cooperation between these groups, and trusts that this situation will be maintained.

Another activity of the chemistry group is the development of processing technologies. The Panel recommends careful consideration of the extent to which the group should be involved in this area within the context of AVRDC's mandate. Since a group from the University of Idaho will come to AVRDC to examine research areas concerned with post harvest technology for vegetables, discussions with that mission will be very helpful.

A major interest in the chemistry group will continue to be human nutrition and the distribution of mineral, vitamins, amino acids, and anti-metabolites in vegetable crops.

5.6 New Vegetables Program

The following description of the background, objectives, and priorities for this program was largely exacted from AVRDC documents.

5.6.1 Background

In view of the diversity of vegetables common to the tropics, the Center has recently initiated two other programs to gather more information on their production and utilization.

The current nutrition garden program and a vegetable adaptability study of five new vegetables were both designed to assist those national level nutrition intervention and vegetable production programs which seek to utilize a wide range of vegetable and legume crops. These efforts will help to narrow the gap between the varietal improvements being made in the private-sector research of developed countries and those being made in the national programs of Asia. The information thus gained will also help AVRDC select additional crops for intensive research in the future.

After evaluating several possible approaches, AVRDC's New Vegetable Committee decided that the program's first phase should consist of two years of variety trials at AVRDC for the following five vegetables: sweet and hot pepper (Capsicum annuum var. annuum.); snap bean (Phaseolus
vulgaris); mustard (Brassica juncea); cauliflower (Brassica oleracea var. italica); and radish (Raphanus sativus).

The objectives of the second phase of this project could be determined after the results of the current trials have been reviewed and evaluated.

5.6.2 Current Objectives

(a) To evaluate the yield and horticultural characteristics of commercially-available cultivars under tropical environments.

(b) To identify major production constraints and potentials for future development.

(c) To generate information for use in AVRDC's nutrition garden projects and bilateral programs, and by the Center's cooperators.

(d) To broaden the focus of AVRDC research and training programs so that they encompass a wider range of vegetables.

5.6.3 Priorities

Phase I:

(a) Using cultivars recommended by seed companies, evaluate the performance of the five selected vegetable under AVRDC conditions, especially during the hot-wet season.

(b) Identify major production constraints such as diseases, insects, and bolting.

(c) Identify elite cultivars (or germplasm resistant to major stresses) for use in other AVRDC programs or in future variety improvement programs.

Phase II:

(a) Duplicate variety trials at AVRDC's bilateral programs (varieties will be recommended to farmers only by the national programs).

(b) Distribute information and germplasm to national programs and cooperators for further trials or varietal improvement.

(c) Conduct similar trials with additional vegetables, or establish and coordinate an "All Tropical Vegetable Evaluation Trial"
Phase III:

Select one or two vegetables for intensive research and varietal improvement at AVRDC.

AVRDC's bilateral programs in Thailand, the Philippines, and Indonesia will conduct further trials of the selected entries for one or two years. The trials will be conducted in both lowland and highland areas of each country in at least two different seasons. After Phase I has been successfully completed, additional vegetables will be selected for similar trials.

5.6.4 Constraints and Achievements

Constraints include the lack of greenhouse space and proper storage facilities. Frequent turnover of committee coordinators and members has created the greatest difficulties for the program.

A total of 646 cultivars from 65 seed sources in 17 countries have been evaluated in observational trials. Of these, 78 elite cultivars were selected for final evaluation trials.

5.6.5 Assessment

The evaluation of commercial cultivars of vegetable crops not included in AVRDC's list of mandate crops (in which varietal improvement is paramount) is an appropriate activity for AVRDC, assuming that arrangements can be made for the establishment of the AVRDC Tropical Vegetable Evaluation Trials.

To be effective, the activities of the vegetable adaptability study should be closely focused on the following objectives:

(a) Providing information on the suitability of the various vegetable crops in the AVRDC vegetable garden program and for adoption in national programs.

(b) Broadening the focus of AVRDC's training and cultural practices research programs so that they deal with a wider range of vegetables.

(c) Evaluating cultivars in international nurseries, both at AVRDC in connection with headquarters training programs, and in outreach programs in cooperating countries.

The Panel commends the results of the Center's study which has produced the proposal for the adaptability study for new
crops, as a preliminary step before adding additional mandate crops to the Center's research activities.

The Panel considers the candidate crops eminently suitable for future adoption as mandate crops.

The Panel is particularly sympathetic to the need for serious attention to the improvement of so-called "traditional" crops found regionally, for which there is very little commercial interest or horticultural attention in national improvement programs.

5.7 Nutrition Garden Program

5.7.1 Objective

The Nutrition Garden Program at AVRDC was initiated with USAID support to examine the potential for small-scale vegetable gardens in circumstances which would not be suited to the development of more traditional or commercial forms of vegetable production. The basic objective of the garden program is to assist in making available a wide range of vegetables to unemployed people or people with very low incomes, who have access to small areas of land and who probably suffering from nutritional deficiencies.

5.7.2 Organization

The Nutrition Garden Program has established four categories of gardens:

School Gardens

School gardens are 10 x 18 meters in size and are capable of providing 70 children with 113 grams of nutritious, culturally acceptable vegetables five days per week for at least a 60 day school term.

Home Gardens

Home gardens are 4 x 4 meters in size and are capable of producing an average yield of 1.5 kg/day and contributing the following percentages of the recommended daily allowance (RDA) for a family of five: Calcium, 72%; iron, 100%; vitamin A, 128%; vitamin C, 506%; and protein, 21%. Research on the home gardens began at AVRDC in June 1981, and in November of 1982 AVRDC began transferring these gardens to specific countries, beginning with Thailand. Since then an economics component has been added to facilitate data-gathering. Nutritionally effective home gardens, which
contain consumer-acceptable vegetables, have been developed for Thailand, Indonesia, and the Philippines.

**Market Gardens**

Market gardens are 10 x 18 metres in size, and are aimed at producing crops that can be sold fresh at local markets, and that have the potential to increase the annual income of poor rural households by about 30 percent.

**Processing Gardens**

Processing gardens are 10 x 18 metres in size, and produce crops that can be processed and sold. The objective of this type of garden is to increase the annual incomes of poor rural households by about 50 percent.

AVRDC scientists recognize that limited economic analysis has been done on the gardens. More economic information is needed to help farmers and policymakers decide whether to support the development of a garden program. Methodologies for collecting the types of data necessary to conduct economic analyses on AVRDC gardens and on farm-family living systems (F/FLS) were adapted for use at AVRDC between April and October, 1982. In November, the home, school, and market gardens were transferred to the AVRDC/Thailand bilateral program for in-country testing, method evaluation, and economic evaluation under controlled Thai conditions. At the same time, pilot study areas in different regions of Thailand were selected to evaluate gardens under actual farm and school conditions.

5.7.3 **Constraints and Future Plans**

The staff of the garden program have prepared detailed estimates of the staff and facilities required to test further the technology and transfer it to other countries, including Indonesia and the Philippines. Staff support is required for AVRDC's nutrition consultant/project coordinator, and for one research assistant, one field assistant, four laborers and one research aide. Additional personnel may also need to be appointed to AVRDC outreach programs.

Equipment and supplies required include fertilizers, seeds, pesticides, hand-tools, and fencing materials.

5.7.4 **Assessment and Recommendations**

The Panel was impressed with the concepts and achievements of the Nutrition Garden Program. The Panel is aware that.
similar proposals have often failed in the past. However, the AVRDC staff involved in this project are obviously highly experienced and have thoroughly researched their proposals.

Because of the potential to grow rice or alternative crops, and because of labor constraints etc., the team felt that the potential for home and school gardens was greater than that for market and processing gardens. The Panel did not have sufficient information, however, on which to base firm recommendations with respect to emphasis on garden types. However, the Panel recommends that the scientists in the garden project evaluate the relative benefits of each garden type with a view to concentrating research and development on one or two categories.

The Panel believes that the garden program successfully complements and enriches the research and development program of AVRDC, and that it is suited to remaining in the NEM program as a multi-commodity vegetable production system. During the reviews of the outreach programs in Thailand and the Philippines, the Panel received favorable reactions to the performance and potential of the garden program. The Panel recommends that AVRDC continues the funding of the Garden Program, preferably from special project funds.

5.8 Soil Microbiology

Soil microbiology as a discipline has been added to the AVRDC core program through the recent appointment of a soil microbiologist seconded by INTSOY. The soil microbiologist is viewed by the management as an important addition who is expected strengthen the crop production programs.

5.8.1 Objectives

The primary goals of soil microbiology at AVRDC are:

(a) The application of research results on plant-soil-microbe interactions to enhance the yield potential of AVRDC crops.

(b) The application of research on plant-microbe interactions that enhance the efficiency of soil nutrient utilization.

(c) The application of research results on plant-soil microbe interactions that result in a reduction in disease from soil-borne pests and pathogens in association with Plant Pathology.
5.8.2 Research Scope

The scope of the present soil microbiology program will mainly concentrate on the study of relationships between Rhizobium species, nodulation, and nitrogen fixing efficiency in soybean. The current activity in the soybean program toward "tropicalization," together with the substantial soybean collection at AVRDC, has made the support of soybean - Rhizobium spp. project attractive to INTSOY. Specific objectives of the INTSOY project will be to assess soybean genotype-Rhizobium strain specificity in relation to enhanced nitrogen fixation efficiencies in different tropical cropping systems, where soybeans are becoming increasingly important. Little work has been done on Rhizobium survival in flooded rice/legume rotations under tropical conditions. Rhizobium survival patterns should be examined in various crops. The development of technologies suitable for the production and application of legume inoculants of Rhizobium could have a considerable impact on improving yields of AVRDC lines grown in national cooperative programs.

In addition to research on soybean, the soil microbiologist will become increasingly involved in research on vesicular arbuscular mycorrhizae (VAM) in relation to increased yield potential in rice, soybean, and tomato. VAM are known to be important in enhancing the uptake of phosphorus by many plant species growing on phosphorus-deficient soils.

Mycorrhizae have been studied in a series of experiments over the past 10 years, beginning first in plant physiology and later continued in plant pathology. The intensively cropped soils around the AVRDC have been found to be rich in a number of VAM species. An important observation made at AVRDC is the survival of high populations of VAMs following a rice crop. In a series of preliminary experiments in the greenhouse, considerable potential for growth enhancement has been demonstrated by adding VAM to the soil.

Another potentially productive area of study in soil microbiology is in research on growth promoting rhizobacteria and other organisms in the rhizosphere. Though this is a field that is presently imperfectly understood, opportunities do exist for research in this area relating to yield enhancement of the vegetables grown at AVRDC.

5.8.3 Organization of Soil Microbiology Activities

At present, soil microbiology is administratively attached to the NEM program where considerable latitude exists for research on various basic and applied aspects of mychor-
rhizae and Rhizobia. The microbiologist has access to a laboratory and one technician working full-time on Rhizobium nodulation studies for the soybean program. Studies with mycorrhizae are carried out cooperatively with pathology, whose plans are to eventually phase out mycorrhizal research as soil microbiology assumes a more active responsibility in the field.

5.8.4 Future Plans

Soil microbiology was established only recently at AVRDC and the senior scientist is presently developing his laboratory and exploring potential research projects in collaboration with the legume and horticultural crops program. Since the existing contract between AVRDC and INTSOY calls for 80% of the soil microbiologists time to be spent on the INTSOY project with legumes, opportunities for research on other crops and problems will still be limited, even though there is some flexibility in time-sharing.

5.8.5 Constraints

The primary constraint at present is the fact that the position is tied by contract to INTSOY for research primarily dealing with soybean Rhizobium interactions. This restricts the degree to which the soil microbiologist can involve himself in other programs in which soil microbiological input may be needed.

Another constraint is the generally high nutrient levels in soils at AVRDC and in surrounding areas. To detect mycorrhizae, low nutrient "native" soils will have to be located for use as testing sites. Another constraint which may limit the experimental partitioning and measurement of the effects of mycorrhizae at AVRDC are the high indigenous levels of mycorrhizae in its soils, a fact which may make experimental work on the addition of mycorrhizal inoculum to crops inconclusive.

5.8.6 Assessments and Recommendations

(a) As positioned at AVRDC via the INTSOY contract, tropical soybean-Rhizobium relations is a well-conceived and well-placed activity. It is entirely appropriate that AVRDC participate in such an activity.

(b) Although AVRDC provides an attractive environment for soil microbiology research, the projects selected for research must be carefully chosen so as to complement the specific needs of the crop commodity programs.
The role of mycorrhizae and other "yield promoting rhizosphere micro-organisms" in promoting crop yields has yet to be widely substantiated. Before such expectations can be realized, significant "basic" research will be needed. The Panel questions whether such research should become an integral part of the core research program at AVRDC. However, the Panel recognizes that research on mycorrhizae could be carried on by visiting scientists or research students.
6. DISCIPLINARY RESEARCH

In the commodity programs there are four disciplines involved in the major genetic improvement of the Center's mandate crops, i.e. Breeding, Physiology, Pathology and Entomology.

The activities of the four disciplines have been discussed in detail in the earlier commodity sections which adequately cover the breeding work. The other disciplines are discussed below from a general point of view with respect to the basic principals of their function, methodologies, laboratory resources, etc.

6.1 Physiology

6.1.1 Background and Objectives

One of AVRDC's objectives is to acclimatize its mandate crops to tropical and subtropical environments. As three of its five crops are adapted to temperate climates, there are wide areas of research which become the responsibility of plant physiologists.

On the basis of the climatic differences existing between the tropics and the temperate zones, research of the plant physiology group concentrates on photoperiod sensitivity and tolerance to high temperature, drought and flooding. Obviously, there are differences in the relative importance of these traits in the various AVRDC mandate crops.

Understanding of photosynthesis, respiration, dry matter production, translocation and partition of photosynthates, source-sink relationships, yield components, etc. are important in attaining high crop yields. Such knowledge becomes more important during the rainy season when solar radiation levels are reduced.

The efforts of the AVRDC physiology group concentrate on crop response to photoperiod, physiological and morphological traits associated with high yield potential, and descriptions of morphological, physiological, and biochemical phenomena which take place during and after the onset of stress conditions in order to understand the mechanisms involved in tolerance to these stresses.

Through these efforts, the objectives are to develop quick and convenient methods to screen large numbers of germplasm accessions for high yield potential and tolerances to various stresses, and to develop crop and soil management methods that permit currently available cultivars to express their maximum yield potentials.
There are several problems which are specific to individual crops; for example, soybean seed viability; flowering and seed setting in Chinese cabbage, and the production of virus-free plants in vegetatively propagated crops such as sweet potato.

6.1.2 Means and Facilities

The physiology group conducts its research as a component of the Legume and Horticultural Crops Programs. The group consists of one Plant Physiologist and three Principal Research Assistants. While the physiologist participates in all research conducted by his group, each assistant is assigned to one or more specific crops.

Laboratory and greenhouse space, the availability of experimental fields, and equipment appear to be adequate, although some of the equipment needs to be replaced.

6.1.3 Research Progress

Some of the physiology research results on each mandate crop are listed below:

**Soybean:** High grain yields are associated with high numbers of pods per unit of field area, which can be increased by increasing planting density; photosynthetic activity both during early growth stages and the flowering to pod filling stages is a limiting factor for high yield; some lines are tolerant to flooding and to mild drought stress; VA mycorrhizas, such as *Glomus fasciculatus* and *G. mosseae* have the potential to increase soybean yields; storability of seed is reduced by high temperature and high moisture content, and is low in large-seeded varieties and high-oil-content varieties.

**Mungbean:** Yield is limited by the partitioning of dry matter rather than the total dry matter production, and it has been shown that the partitioning of dry matter to grain can be increased by having more pods; response to photoperiod occurs not only during the pre-flowering phase but also during the flowering phase; mungbean is sensitive to drought conditions, especially at the flowering stage, and there is a varietal difference in this stress sensitivity; some lines have flood tolerance; germination and seedling growth are sensitive to low temperature (15°C seems to be critical).

**Tomato:** High day and night temperatures are detrimental to fruit set, and high temperatures above 30°C
cause various abnormalities to the reproductive organs due to decreased levels of the endogenous auxin and gibberellin; auxin application on open flowers results in parthenocarpic fruit set and fruit yield increases under high temperatures; a few cultivars have acceptable fruit setting ability under high temperatures; flooding injury is mostly due to reduced supply of $O_2$ to the roots, and is accelerated by high air and soil temperatures; some accessions are relatively tolerant to flooding, but the tolerance is lower than that of other vegetable crops.

Chinese cabbage: Heat tolerant accessions possess various common physiological characteristics which are related to high turgor in the leaves; N, K and Ca balance is disturbed by high temperatures; some accessions are relatively tolerant to flooding; head yield is negatively correlated with the accumulated degree-days above a mean temperature of 23°C during the growing season in heat sensitive entries, and with the accumulated precipitation above 40 mm/day in heat tolerant entries: the critical low temperature that induces flowering in heat tolerant entries is about 14°C; artificial cold treatment of 5°C for 20 days effectively induces flowering in heat tolerant seedlings; the critical photoperiod for vernalized plants is about 12 hours; and when vernalization is incomplete application of gibberellin induces flowering.

Sweet Potato: Five elite lines that produce consistently high yields in the wet season were identified as breeding lines; the partitioning of photosynthates appears to be more important for storage root development than total dry matter production during the hot, wet season because leaves and stem compete with storage roots as sinks for photosynthates.

6.1.4 Strategy and Future Plans

Future plans for research follow more or less a similar strategy to that of past years. Major subjects for research continue to be seedling emergence potential, drought stress and flooding stress in soybean; the physiological basis of high yield, drought stress and flooding stress in mungbean; heat and flooding tolerance in tomato and in Chinese cabbage; and drought and flooding tolerances, and meristem culture in sweet potato.

6.1.5 Assessment and Recommendations

The physiology group operates as one of the components of the crop research programs. Since there are five mandate
crops, the group is required to cooperate with these five crop committees, each having a few major research areas. Thus, the list of priority research subjects is bound to become excessive to a physiology group which has only one senior scientist.

There is serious danger under these circumstances that the quality of research may be eroded by this pressure, and the depth of the research may suffer. The group has been trying hard and has had some success in producing results.

Within the context mentioned above, the physiology group is encouraged to concentrate on fewer carefully selected priority research items, such as seedling emergence potential of soybean, yield potential of mungbean and sweet potato, and setting and development of tomato fruits under high temperature. To this end, some additional equipment may be necessary, e.g. a fluorescence microscope.

The tissue culture work of sweet potato will be transferred to the seed laboratory, once the process becomes routine. The routine procedures are now being codified.

The Panel feels that the physiology group should provide breeders with convenient and quick methods to screen germplasm and breeding lines for useful characteristics, but the development of such methods is possible only if breeding targets are well identified and agreed to by breeders and physiologists. Under the present situation at AVRDC, even with such an agreement, it would be difficult to achieve such a goal without adding at least a small number of junior members to the group.

Some of the problems may not be solved by breeding in the near future, or perhaps even in the distant future. To deal with these problems, there are areas of research in agronomy and cropping systems to which the physiology group could make a contribution. The Panel feels that comparison of various physiological traits between crops, in addition to within crop germplasm, may be useful. Crops other than the Center's five mandate crops could be included in these comparisons. Some preliminary work has already been undertaken. In relation to this proposal, the Panel recommends the compilation of all of the available data on environmental conditions (including climate, topography, soils, etc.) in the target areas to identify suitable sites and seasons that could be exploited by various crops. This should be carried out in cooperation with the NEM program.

The panel notes that the physiology group has made a considerable contribution in describing various phenomena
related to the improvement of all AVRDC mandate crops, and recommends that the group identify a few priority items on which they concentrate their effort in order to have a greater impact on those aspects of screening that they can pursue in depth, and thereby increase their effective input into crop improvement.

6.2 Plant Pathology

6.2.1 Background

Because the tropical environment permits continuous vegetative growth without a fallow period, pests and diseases easily find alternate hosts, and can multiply year round. Furthermore, because disease-free seeds are usually unavailable, pathogens are often spread during planting. Since many of the diseases present in the tropics may not be found in the temperate zones, little information is available on them. Because of environmental differences, information from the temperate regions on diseases found in both tropical and temperate regions is not always useful. Diseases of minor importance in the temperate regions (e.g. bacterial wilt and late blight of tomato) are often major problems in the tropics.

6.2.2 Approach and Objectives

The pathology program is problem-oriented, and emphasizes the improvement of host resistance or tolerance. Host plant resistance is the most effective and least expensive method of controlling plant diseases, and is easily extended to small farmers.

The objectives of the pathology program are: To assess the importance of various diseases in the tropics; to identify and improve host resistance or tolerance; to study how the pathogen, the host, the environment, and the interactions thereof influence the disease incidence and resulting yield losses; to develop integrated cultural, biological, and chemical control practices, and to determine the feasibility of improving VA mycorrhizal associations.

6.2.3 Role of Pathology

Research in plant pathology is largely directed to a responsibility or need identified within a particular Commodity Group. This research has been thoroughly reviewed under the respective crop sections of this report. From the standpoint of plant pathology, however, research activities can be classified into the following categories:
(a) Characterization and quantification of diseases and their relationship to yield loss.

(b) Development or improvement of screening and selection methodologies.

(c) Evaluation of resistance in accessions and advanced lines.

(d) Identification and characterization of resistance.

(e) Epidemiological studies.

(f) Studies of cultural, biological, and chemical controls.

(g) Studies of mycorrhizal associations, primarily in rice/soybean cropping systems.

In addition, plant pathologists directly support the activities of the Center by 1) supplying inoculum for screening tests conducted by the commodity improvement programs, 2) identifying disease problems for research staff and training scholars; and 3) recommending disease control measures in test trials of seed production plots.

Plant pathologists also work closely with AVRDC's training program by providing formal classroom instruction for trainees, by hosting program oriented scholars, and by training breeding staff in the use of current screening and selection methodologies.

6.2.4 Disease Problems on Hand

The plant pathology staff deals with more than 23 fungal, bacterial, and viral diseases of five commodities. Ten or more of them are considered to be of major importance. The amount of time devoted to each disease and the degree of understanding and progress achieved varies. In some instances solutions have already been found, but in other cases the problems are just beginning to be explored. The diseases under study are listed below.

**Soybean**: Rust, anthracnose, bacterial pustules, downy mildew, mycorrhizal fungi (not a disease), and various soybean viruses.

**Mungbean**: Powdery mildew, Cercospora leaf spot, root rot disease complex, mungbean viruses, seed-borne and soil-borne diseases.

**Tomato**: Bacterial wilt, tomato mosaic virus, late blight, root knot nematode, tomato leaf curl, cucumber mosaic virus, potato virus-Y.
Chinese cabbage: Downy mildew, soft rot, turnip mosaic virus.

Sweet Potato: Mycoplasma-like organisms, viruses.

6.2.5 Staff

Apart from plant breeding, plant pathology is the most heavily staffed discipline at AVRDC. Three senior scientists are assisted by eight full time assistants. Two visiting post-doctoral scientists are also involved in the program, as are six administrative, technical, and lab assistants and 20 field support staff.

The pathology research program is measurably enhanced by visiting scientists, training scholars, and pre- and post-doctorate fellows, including Ph.D. candidates. These scientists are actively recruited to work on projects that promote the overall pathology group's effort.

6.2.6 Cooperation

The research scientists are members of two or more interdisciplinary commodity teams, and are therefore responsible for coordinating their activities both within and between the commodities they are responsible for. Project priorities are proposed by the senior scientist after consultation with the commodity team and plant breeder. Coordination occurs during commodity group meetings and on an individual level.

Administratively, all staff in plant pathology, including labor, are assigned to either the horticulture crop or the legume crop pathology sections. Because of constraints, however, pathology generally operates as a unit to promote efficient use of personnel, expertise, facilities, and budget. The research scientists are nonetheless responsible primarily to the programs (horticulture or legume) to which they have been assigned by the Director General.

6.2.7 Achievements

Pathology works as a part of the commodity teams. Accomplishments are described under various crops.

6.2.8 Constraints

Apart from those constraints normally associated with budgetary limitations, Plant Pathology operates under two major constraints caused by its location. The first is the seasonal
nature of some important tropical diseases in Taiwan (sub-tropics) and the absence of some important pathogens, and the second results from the fact that AVRDC is located within a prime agricultural area, which thus limits large scale field experiments involving air-borne pathogens.

In addition to these constraints, certain kinds of research suffer from a lack of controlled environmental facilities. Then, too, because of the great demand in Taiwan for trained plant pathologists, a high turnover of junior research staff has slowed research progress in some projects.

6.2.9 Assessment and Recommendations

The Panel feels that considerable progress has been made in Pathology toward the resolution of specific disease problems. Many sources of resistance have been identified. Some of those which have been put into practical use by breeders include resistance to powdery mildew and Cercospora leaf spot of mungbean, and bacterial wilt of tomato.

Pathology faces a large number of disease problems in five different crops. The Panel recognizes the need for additional manpower and recommends that the administration consider hiring an additional senior staff member and a number of junior researchers.

The Panel feels that it might be possible to concentrate on fewer important diseases. However, more attention should be paid to the virus diseases. One area is the yellow mosaic virus which is a major problem of soybean and mungbean in the Indian sub-continent, and is a potential threat in other producing areas. The virus diseases of some crops are presently in the early stages of exploration.

To facilitate the study of the effects of environment on disease development, the Panel recommends the provision of some greenhouse and controlled environmental facilities. However, elaborate phytotron facilities are beyond the financial capability of the Center.

Although mycorrhizal research has great potential, the Panel feels, however, its relation to pathology is peripheral, and that the program's involvement should be minimal in view of its other responsibilities.

Most plant pathogens have different races or strains, and they vary in their pathogenic activity. The Panel feels, whenever possible a collection of each group of pathogens existing in Taiwan be accumulated and maintained at the Center as working or reference materials.
The Panel also feels that a rapid and dependable method of
virus indexing which meets the requirement of international
plant quarantine should be developed soon in order to
facilitate the distribution of sweet potato germplasm.

6.3

Entomology

6.3.1

Introduction

From its inception AVRDC has recognized entomology as a
means of improving the yield and quality of vegetable crops
in the tropics and subtropics. Vegetables are often grown
intensively, on the same piece of land for several years, and
are subject to pest attacks which can reduce yield and
quality. Insect damage is a particularly conspicuous form of
quality loss, and marketability often depends on the absence
of insect damage, even when losses in the actual amount or
volume of produce is insignificant.

In many countries, insect damage has led to the indiscrimi­
nate use of pesticides which, in turn, poses hazards both to
consumers and the environment. Conscious efforts are now
being made to reduce the quantities of pesticides applied to
vegetable crops, but, despite these efforts, vegetable crops
continue to be over-sprayed to meet marketing requirements.

In developing countries, vegetable crops which require little
or no chemical inputs have the dual advantage of safety and
reduced production costs. Producers in these countries can
ill-afford to use chemicals, even in intensive vegetable
production. To them the AVRDC approach of placing em­
phasis on vegetables with resistance to major insect pests
constitutes a meaningful input into vegetable production
systems.

However, stable insect resistance may not be found, or may
be difficult to find, in cultivated crops, most especially in
vegetables which are attractive to insects for the same
reasons that make them attractive to people. Some cultivars;
or lines that have been identified as resistant or moderately
resistant have become susceptible within two generations. It
is therefore important that in vegetable improvement, the
possibility of alternative mechanisms that are safe and
compatible with production systems and consumption
requirements be kept in mind. This AVRDC has done.

6.3.2

Current Status

AVRDC appointed its first entomologist in 1973, and has
always had an entomologist working in collaboration with its
various commodity programs. At present, the entomologist
works on insect pests of soybean, mungbean, tomato, Chinese cabbage, and sweet potato. Theoretically, he spends about 20% his time on each of these crops, but in practice time allocation varies from season to season, depending on crop production schedules, pests incidence, and the intensity of field and laboratory resistance screening.

AVRDC mandate crops are attacked by a variety of insects, from the seed and seedling stages to harvest. In nearly all cases, there are one or two major species that need to be controlled or for which resistance must be sought. On legumes, there may be more.

Although all of the Center's mandate crops are subject to entomological study, entomology is not considered a service discipline since it deals with production loss and/or quality loss. Insect control significantly affects yield and marketability, and may account for huge differences in the farmers' income. Furthermore, entomological research in the form of reliable screening of breeding lines and cultivars for insect resistance has a major role to play in the production of improved cultivars for distribution. Because of the importance of insect attack on most vegetable crops, there is a tendency to involve entomology in every program. It must be stated however, in vegetables as in other crops, that not all insect injury constitutes a pest problem, and a careful study of insect/crop relationships must be made before major target species are selected for research attention.

6.3.3 Research Strategies

Entomological research strategies at AVRDC include:

(a) The search for and identification of host plant resistance to major insects in the mandate crops.

(b) The development of appropriate integrated pest management systems that can be adapted to vegetable production systems in the tropics.

(c) The avoidance of a reliance on pesticides as a major means of pest control.

The Panel considers these strategies to be appropriate within the context of AVRDC's mandate crops and the clientele that it serves. Research to date has placed considerable emphasis on the genetic mechanism of resistance in the accessions and the cultivars being developed. It must be pointed out that in nearly all cases these efforts have not resulted in stable resistance to any major insect species.
This is not totally unexpected in view of the fact that in nearly all cases a complex of insect species is involved. Furthermore, the basis of resistance to insects in plants often involves undesirable plant characters or concentrations of chemicals which are unacceptable to humans.

An example of the complexity of the problems faced in host plant resistance screening is evident in the work being conducted by AVRDC with soybean and mungbean. In these cases, three species of beanflies infest the seedling stage; one is a pith feeder and two feed under the epidermis. The accessions which are resistant to the pith feeder are not necessarily resistant to the sub-epidermal feeders. In addition these crops are attacked by pod borers, (2-5 species), stink bugs (3 species) bruchids (2 species), and foliage feeders. Experience elsewhere suggests that the process of identifying and combining resistance to such a complex of species can be an extremely long process, and is often unattainable. It is therefore often beneficial to diversify the approach to these problems by looking at alternative pest management systems that do not exclude the use of resistant cultivars.

All these do not negate the importance of searching for acceptable host plant resistance, but are mentioned only to focus attention on the need to combine various pest management approaches so as to generate useful, early results. In other words, while the search continues for resistance, the tropical vegetable grower can derive major benefits from AVRDC's advance lines within his own biological and economic circumstances. When resistant cultivars are obtained, they can then be incorporated into an integrated pest management system (IPM). IPM should also feed information back to research in such a way as to influence breeding objectives, and to focus on what is achievable within established vegetable production and pest management systems.

The state of research on vegetable pests at AVRDC and the progress achieved thus far has led the Center to shift toward research on the development of integrated pest management. Some of the essential components of suitable management systems have already emerged from previous research. There is now a fundamental need to adopt a broad-based biological approach to the study of specific ecosystems in which vegetables are produced, with a view to managing, the crops and pests in such a way as to substantially reduce losses or damage. This strategy would require more resources than are now made available, and there is a need to conceptualize, design, and test pest management systems incorporating all compatible pest control methods, including natural enemies, resistant cultivars, crop...
management practices, pheromones, chemicals etc, into a multi-faceted program. In view of the nature of IPM, basic systems design could be done at AVRDC, but adaptation, modification, and implementation should be investigated at the national programs level.

The Panel notes that in the case of diamondback moth, AVRDC is giving serious consideration to the use of natural enemies for biological control. The Panel recognizes that the prospects for this approach are good in island states such as Taiwan and the Philippines, and possibly in other AVRDC participating countries. The Panel recommends that careful consideration and attention be given to all pre- and post-importation precautions, including host specificity and hyperparasite studies, and also to effective planning with the involvement of national programs. The Center should consider obtaining special project support for this biological control project which, if successful, could be of great benefit to the countries concerned and to the scientific community at large.

The Panel also endorses the proposal of AVRDC to sponsor an "International Workshop on Diamondback Moth Management" early in 1985. It notes that it is the intention of AVRDC to use the opportunity to bring together leading scientists working on this problem to discuss possible approaches in the hope that the deliberations will help AVRDC to sharpen the focus of its diamondback moth program. The proposed informal network should be useful in the design, adaptation, implementation, and refining of IPM programs for this pest.

6.3.4 Constraints, Assessment and Future Plans

The constraints that have been identified for entomology fall broadly into two categories: Staff and facilities.

Staffing: A review of the entomological research at AVRDC and the entomological inputs required in the Center's five crop programs clearly indicate that staffing is inadequate. It is impossible for one entomologist to adequately cover the basic strategies of screening and developing resistant cultivars on the one hand and developing integrated pest management systems for five individual crops on the other.

The Panel recommends that as a matter of priority, a second entomologist be recruited. One entomologist should be assigned to the Horticultural Crops Program and the other to the Legume Crops Program.

It has been suggested that the second entomologist should be an insect physiologist who can develop artificial diets and
elucidate physiological mechanisms in insect plant relationships and weevil nutrition. The Panel is of the opinion that this would not be appropriate. While some limited work on mass insect rearing and the development of diets is important, this type of work should be undertaken and maintained by a well-trained technician or research assistant, possibly in cooperation with other centers.

The Panel considers that the first priority of research should be directed at developing integrated pest management systems for the major pests of AVRDC's mandate crops. This work will involve the study and characterization of vegetable production systems; the conceptualization, design, and implementation of pest management systems conducted in collaboration with national programs; studies on seasonal biology and insect population dynamics; crop/insect relationships; pests/natural enemies interactions; identification of suitable agronomic/cultural practices; and studies on the effects of minimum pesticide applications on target and non-target organisms, with special concern for species which are presently rated as minor pests. This ecosystem approach requires a well-trained and experienced entomologist in the principles and practices of integrated pest management. The Panel therefore recommends that the entomologist be recruited in the area of integrated pest management. Such an appointment will complement the existing entomological work and strengthen the direction which AVRDC has itself identified as a priority area.

It is important that the second entomologist should have the necessary research support staff, both in terms of the laboratory work and the field work.

The Panel considers insect physiology to be a second priority. If insect physiology become a limiting factor, cooperation should be sought with institutions such as the International Center of Insect Physiology and Ecology (ICIPE). This may involve visiting arrangements and/or collaborative research, on specific insect physiology problems.

Facilities

The facilities for entomological research at AVRDC need to be upgraded to provide for the type of work envisaged in the long term plan. The Panel considers that only limited work on insect rearing will be required and that controlled environmental rooms will not be required. It is recommended that a limited number of large incubators with temperature and humidity control be purchased for the species of insects in which mass rearing will be required. It is important to
point out that laboratory screening for resistance cannot replace field screening. Facilities will need to be strengthened for field screening to take place in known centers of high incidence and multiple species occurrence, e.g., Indonesia for beanflies, or where the pests are known to occur the year round.

In terms of integrated pest management, facilities and travel budgets will need to be strengthened, especially for collaborative work with national programs for adaptation, design, and experimentation with modified pest management systems. Such collaborative work could also make important contributions to the design and testing of IPM systems at AVRDC and at other locations.

The Panel recommends that when a second entomologist is appointed, a review of the entomological research work at AVRDC be conducted with a view to establishing a careful balance between host plant resistance work and the development of pest management systems for the legume and horticultural crops. Such a review should include a careful and realistic assessment of the potential for success in identifying host plant resistance, the number and complexity of insect species involved, and the feasibility of putting together the components of a pest management system that assures the full or partial attainment of the potential of adapted improved materials being made available to national programs.

On the whole, entomology as a discipline has made important contributions to the legumes and horticultural programs at AVRDC in the definition of pest problems, the identification of host plant resistance, and the investigation of some essential components for the development of implementable pest management programs.

The time is now ripe for the discipline to amplify its work by becoming more intensively involved in the design, development, evaluation, and implementation of pest management systems for the crops and the production systems associated with AVRDC's mandate.
7. **SUPPORTING RESOURCES AND SERVICES**

7.1 **Genetic Resources Unit**

7.1.1 **Background**

AVRDC's Genetic Resources Unit (GRU) stores and conserves more than 23,000 accessions of the Center's five mandate crops, as well as several hundred accessions of other vegetable crops. These accessions provide the genetic variability that is required by the breeders for varietal improvement work.

Seed samples are made available to cooperators from national, regional, and international programs. Anywhere from 12,000 to 20,000 seed samples are distributed annually. Under an arrangement with the IBPGR, a duplicate set of the entire AVRDC mungbean, tomato, and Chinese cabbage germplasm in the IBPGR gene bank has been sent to the Institute of Plant Breeding, Los Banos, Philippines for safe-keeping. The Chinese cabbage collection is also being transferred to the National Vegetable Research Station in Wellesbourne, UK, for long-term storage.

7.1.2 **General Objectives**

The objectives of the AVRDC Genetic Resources Unit are:

(a) To collect systematically and conserve germplasm resources for AVRDC's mandate crops;

(b) To purify, characterize, catalogue, and publish information on all germplasm accessions;

(c) To preserve the germplasm in long-term storage, either at AVRDC or at other germplasm banks;

(d) To conduct research on seed production, seed treatment and storage;

(e) To provide pre- and post-entry quarantine services; and

(f) To provide training on germplasm, seed production, and quarantine.

7.1.3 **Organization and Procedures**

Germplasm conservation and seed research is centralized in the Genetic Resources Unit. The unit is headed by a senior staff scientist. The GRU is in charge of collecting,
conserving, maintaining, and cataloging germplasm materials. The unit maintains facilities for seed storage, processing, and analysis. The unit also conducts seed production research. Accessions are characterized according to the IBPGR descriptor lists. The processing of seed requests and seed distribution are the responsibility of the germplasm unit. The Genetic Resources Unit has been designated by the IBPGR as a world repository for mungbeans and a regional (Asian) repository for sweet potatoes.

7.1.4 Staffing, Equipment, and Facilities

Staffing

The present staff includes one senior seed technologist, one post-doctoral fellow (under IBPGR auspices), two research assistants, one field assistant, one research aide, and one laboratory helper.

Facilities and Equipment

Existing facilities include short- and medium-term seed storage rooms and facilities for seed processing and packaging. These facilities are generally considered inadequate for the size and volume of work carried out by the unit. A new US$150,000 germplasm unit is scheduled for construction in June of 1984. Construction will be funded, in part, by the ROC's Council for Agricultural Planning and Development. The facility will have a general office, short- and medium-term seed and tuber storage space, seed handling and packaging space, a wet laboratory, a general laboratory, and rooms for germination, tissue culture, pathology, seed preparation, and computer services. There will also be ample space for drying, potting, and green house work. The tissue culture facility within the seed lab will be responsible for producing virus-free sweet potato clones and other types of germplasm and breeding materials for shipment to national programs.

7.1.5 Accomplishments

a. The Genetic Resources Unit maintains under short- and medium-term storage a 23,000 accession collection (10,524 soybeans, 5,016 mungbean, 5,112 tomatoes, 812 Chinese cabbage, and 1,200 sweet potato).

b. The method for seed multiplication in Chinese cabbage has been upgraded from hand-pollination to bee pollination.
c. Germplasm has been provided to cooperators in 148 countries.

d. Tomato and sweet potato accessions have been characterized, and computer printouts are now available.

7.1.6 Future Plans

The construction of the new seed laboratory will increase storage capacity for additional collections of the five mandate crops, as well as other vegetables commonly used in tropical cropping systems (including vegetable gardens). Research on improved methods of seed processing, packaging, storage, and germination, as they are influenced by ambient relative humidity and temperature, will be intensified. A computerized inventory system on seed maintenance, varietal cataloging, and information retrieval will be established.

The construction of a post-entry quarantine house for sweet potato is being funded by IBPGR. Organized collection trips to fill collection gaps are contemplated. The germplasm unit also plans to undertake tissue culture propagation of sweet potato clones and other asexually reproduced vegetables.

7.1.7 Assessment and Recommendations

The AVRDC Genetic Resources Unit represents a unique and invaluable regional and world resource of germplasm. The philosophical position taken by the GRU in maintaining a wide diversity of germplasm of each AVRDC crop as individually distinct accessions is entirely in keeping with its recognized position as a world germplasm resource.

The Panel recommends support for the activities of the GRU, and that the leadership within the unit work actively to generate additional funds for special research activities from interested agencies. Because of the time-consuming demands of accession characterization, a high priority should be assigned to computerizing seed inventories, passport information, and characterization data. It is in these areas that additional assistance from the IBPGR might be sought. Specialized characterization data collection forms could be developed and sent out with each accession so seed recipients could be assisted in the process of characterization.

Because the AVRDC germplasm collection represents an active working collection which also has loose collection responsibilities in certain crops, there are unique opportunities for research and training of specialists in the area of germplasm conservation. The existence of the GRU
encourages the participation of trainees and visiting scientists.

As characterization and evaluation data for accessions are accumulated in the computer data bank, these data will be made available to researchers through the distribution of the catalogs produced.

The Panel supports the plans of the GRU to identify the collection gaps in each group, and on this basis obtain needed materials from other collections or by mounting its own collecting trips. IBPGR is currently assisting with the passport data collection for Chinese cabbage from Japan and Korea, and is contemplating a collection mission in Southeast Asia.

Tissue Culture Activities

Tissue culture activities have been carried largely in the plant physiology laboratory, and are focused on meristem tip culturing of sweet potato breeding lines for the purposes of ensuring that distributed clonal materials are disease-free, and that they will pass phytosanitary inspection overseas.

In recent research planning, this tissue culture activity is seen as a function to be carried out by the seed laboratory of the Genetic Resources Program. A tissue culture facility has been planned for in the new seed laboratory, and should be available late in 1984 or early in 1985.

Although there may be a need for tissue culture as a research tool in any number of the scientific disciplines supporting the various program areas at AVRDC, the development of further tissue culture facilities should be based on a demonstrated need developed through the normal channels of research management.

7.2 Statistical and Computing Services

7.2.1 Background

Until recently, budget limitations have meant that leadership in statistical and computing services has been provided on a part-time basis by AVRDC agricultural economists. Two-year appointments in statistical services are now funded directly by the Japanese government, with the second of these appointees taking up his position in May 1984.

Computing services have historically been provided via land-lines to IBM computers in Taipei. Subsequently,
smaller jobs were processed on NEC microcomputers at AVRDC, and word processing was done on an IBM display-writer located in the Office of Information Services. There are no facilities for data exchange between the three sets of equipment. AVRDC has recently conducted a major review of its data processing/word processing requirements. At the time of the Panel's visit, the Center was in the process of introducing a network of Hewlett Packard (HP) microcomputers linked to an HP minicomputer to be purchased for the library's TVIC project.

7.2.2 General Objectives

Statistical and computing services at AVRDC are currently in a state of flux. Objectives for the services have not been formally stated as yet, but should include: provision of assistance in the statistical aspects of design and analysis of biological and economic experiments and surveys; maintenance of data base management systems for the library TVIC project, germplasm unit, inventories, and mailing lists; maintenance of and assistance with word processing facilities; facilitation of data transfer between the HP system and other devices such as the IBM Display Writer; field and laboratory data loggers; and support for administrative systems.

7.2.3 Organization and Procedures

Under the old system, access to data processing equipment was limited to the statistical and computer services staff. Scientists submitted data sheets and received the results of analyses a few days later. There was little assistance with the design of experiments. Difficulties encountered in using the terminal to Taipei (for large jobs) included limited access times and limited availability of data storage.

The new system should overcome many of these problems by providing researchers with immediate access to "stand alone" microcomputers for smaller jobs and time-shared access to the HP minicomputer for larger jobs.

It would be desirable for the statistician to monitor the statistical and computing work of researchers to ensure that analytical standards are maintained, if not improved. It would also be desirable for the statistician to have greater involvement in the planning and design of experiments than appears to have been the case in the past.

Under the old system, all word processing work was done on a single unit in the OIS. The new system will allow AVRDC secretaries to type documents directly into the network for eventual transmission to high quality printers without the need for re-typing.
The new system also has desirable implications for the organization and procedures of the library, administrative departments, and genetic resources unit.

7.2.4 Staffing and Equipment

The statistical and computing services group includes one principal staff member and three regular staff members. With the acquisition of the HP system, equipment will include one HP 3000 S/42 (1 megabyte random access memory - RAM), 1 disc drive, 1 tape drive, 1 printer, and 16 communication channels. Network microcomputers will include 12 HP 150s, 2 NECs, 1 APPLE and 1 Zenith, together with screens and dot matrix printers. High quality printers are to be located in the library and Director General's office. The approximate cost of the new equipment is US$150,000, part of which will be met by the IDRC/TVIC funds.

7.2.5 Accomplishments

The main accomplishments of the group have been in providing data processing services to scientists, and developing computer packages for statistical analyses on the NEC microcomputers. The planning of the new computer system is an important accomplishment for AVRDC. The review team believes that the proposal has been thoroughly researched and supports its introduction.

7.2.6 Assessment and Recommendations

The Panel believes that the statistical and computer services group has been seriously under-manned and under-equipped in the past, largely because of budgetary constraints. Japanese funding of the principal scientist position has helped to relieve the staffing problem.

The Panel believes the position is extremely important to AVRDC functions and recommends that, if Japanese support for the position is terminated at some time in the future, efforts be made to fund the position from the core budget. The Panel also recommends that the statistician should have greater involvement in experimental design than appears to have occurred in the past, and that he should assist researchers in performing their own analyses in order to maintain statistical standards.

The proposed computer system should largely overcome equipment problems at a modest cost. The Panel supports its introduction. However, the Panel has reservations concerning the compatibility of HP software with other
computers, especially those at other IARCs. However, the choice of HP system was heavily constrained by the fact that the TVIC/IDRC project is committed to using the MINISIS package which can only run on HP equipment. In addition, only two computer companies, including HP, could offer adequate backup services in Taiwan.

7.3 Office of Information Services

7.3.1 Objective

AVRDC lists the following objectives for the Office of Information Services: To assist in increasing the level of communication between AVRDC researchers and their colleagues working in national programs; to assist in the dissemination of the Center's finished research products, i.e. new varieties, management practices, and training programs; and to serve as a link between the Center, its donors, and other audiences interested in AVRDC activities.

7.3.2 Organization and Procedures

The Information Officer reports directly to the Director General, consults with a Program Leader Advisory Committee, and responds to requests from research and administrative units. The primary activity of the unit is the editing and preparation of publications which are distributed mostly free of charge to a mailing list of about 6,000 people in 140 countries. Fifty per cent of subscribers are in Asia.

Publication strategies have varied in the past in a search for the mix of publications that best satisfies the needs of different audiences. The OIS now attaches priority to producing an annual Progress Report and Progress Report Summaries, journal papers, symposium proceedings, technical bulletins, and the AVRDC newsletter – CENTERPOINT.

Communication services for AVRDC staff, including photography, art work and printing, account for about half of the OIS expenditure on staff and supplies. The OIS as a source of information is important for the Center's public relations, and AVRDC activities achieve significant coverage in the national and international media.

7.3.3 Staffing and Facilities

The OIS has fewer staff than similar units in most other IARCs. The present staff consists of one principal staff member, one temporary intern, and seven regular staff. The OIS 1984 budget totalled US$103,000 - salaries 70 per cent, supplies and equipment 30 per cent.
OIS equipment includes an IBM Displaywriter (word processor) purchased in 1982, outdated photographic equipment, minimal equipment for artwork, and an aging printing press that requires constant maintenance.

7.3.4 Accomplishments

Despite severe constraints in terms of staff and equipment, the OIS has been able to disseminate widely an impressive array of publications and to meet the requirements of the scientific and administrative units in terms of communication services.

In 1983, the OIS edited 27 reports, printed 1 million pages, produced 23,000 slides and photographs, prepared 150 art jobs and distributed 40,000 publications. There has been a good response to recent publishing initiatives. In particular, distribution of the newsletter CENTERPOINT led to 1,700 special publication requests and 400 requests for seed in 1983.

7.3.5 Future Plans and Constraints

The OIS intends to improve still further the layout and content of some of its publications, particularly the annual Progress Report and the Project Report Summaries. The mailing list is to be rationalized by a questionnaire to ascertain readers' interest in remaining on the list. Following a survey of readers, the OIS plans to introduce air mailing for despatch of publications to some countries. A policy of charging for the major publications (annual progress reports and symposium proceedings) is being instituted.

The introduction of the HP computer network should relieve some of the present work load, particularly the typing of documents on the word processor. However, there will be additional editorial and printing work associated with the library's TVIS project and general increases in other loads as AVRDC research output expands.

English is the predominant language for OIS publications, but is a second language for most AVRDC staff. This situation places heavy loads on the editorial staff and represents a possible constraint to increased output from OIS.

Most OIS equipment is due for replacement in the next two or three years. It may not be possible to arrange for suitable commercial English type-setting services in Taiwan, and this may require the purchase of a phototypesetter, which will represent a major capital investment.
7.3.6 **Assessment and Recommendations**

Like many other AVRDC units, the OIS has managed to produce large quantities of high quality work using small numbers of talented staff and minimal equipment. The review team is of the general view that it is time to increase the OIS staff complement and upgrade the unit's equipment.

In particular, the Panel endorses the Center's plan to acquire the services of a second editor. The Panel notes that AVRDC is formally evaluating the type-setting/printing options available with a view to replacing the existing press and purchasing a phototypesetter. The Panel supports the publication strategies of OIS and the charging policy soon to be announced. Panel endorses the plan to improve the Progress Report Summaries by adding a highlights section. The Panel also suggests that some material from the Progress Report Summaries be incorporated into the Progress Report to avoid confusion, and to make the Progress Report more useful as an annual report of not just the research activities of the Center, but on all AVRDC activities.

7.4 **Library and Documentation Center**

7.4.1 **Objectives and Priorities**

The library aims to provide AVRDC staff and trainees with research information and to establish a worldwide collection of literature on vegetable crops and supporting sciences.

Priority is given to AVRDC staff and trainees but other national and international users are also served. Present holdings emphasize AVRDC mandate crops, but attention is also paid to other tropical and subtropical vegetables.

7.4.2 **Resources and Operation**

Five staff members are allocated to the library, including a senior librarian and a catalogue librarian. The library holds approximately 16,000 titles on AVRDC mandate crops, 9,000 book titles (including reports, theses, etc.) and 950 serial titles. Acquisitions are monitored by the Deputy Director General and the Senior Librarian. Holdings are reviewed by all senior research staff every two years.

The library performs the function of a special agricultural library, but also operates as a documentation center on vegetable crops and as a selective disseminator of information services, providing access to computerized data bases through the assistance of USAID.

The library has established exchange relationships with 192 libraries, experimental stations, and government agencies
throughout the world. It also participates in a number of national and international networks, including the international Agricultural Research Centers' Library Network and the International Information System for Agricultural Science and Technology.

7.4.3 Accomplishments, Limitations, and Future Plans

The library is able to provide adequate services to AVRDC staff through its own collection, which meets about 70 percent of scientists' immediate needs, and through the use of inter-library loans and reprint services. The library staff has also compiled bibliographies and sets of abstracts in areas of specific interest to AVRDC scientists.

The availability of staff and funds limits the services offered by the library, but these constraints do not appear to be too severe. The library has been able to manage a substantial collection with a smaller staff than some of the other IARCs. The library staff feels that there will be sufficient space to allow modest expansion of the collection in the future.

Library activities are to be expanded in the form of a Tropical Vegetable Information Center (TRIC), partly funded by IDRC (Canada). The TVIC will become a world center for the computer storage of information on mungbean, soybean and Chinese cabbage. Part of the IDRC grant is to be allocated to the purchase of Hewlett Packard 3000 mini-computer to allow the use of the bibliographic package MINISIS. Acquisition of the computer system will also allow computerization of other library activities - borrowing, bibliographies, serial listings, etc.

In summary, the AVRDC library compares favorably with other IARC libraries and the Panel supports the future developments foreseen.

7.5 The Experimental Farm

The Experimental Farm is the responsibility of the Farm Superintendent who reports administratively to the Deputy Director General.

A Crop and Land Management Committee (CALM) defines the principles of land use at AVRDC. Two years ago, a decision was made by this Committee to divide the 80 ha of land assigned to the field experimental activities on the basis of programs and disciplines. Each section has its own land and manages its area according to its individual needs.
Normally, the experimental fields are rotated with paddy rice every two or three years to remove the residual effects of fertilizer. Rice grown on the farm is contracted by AVRDC with neighboring farmers. Paddy fields currently occupy approximately 30 ha of the farm. Fallow land is either deep-plowed or planted to green manure.

Although the Farm has developed an improved irrigation and drainage system to obtain more consistent results, heavy rain and drought create periodic problems.

Topography and inadequate drainage systems on neighboring lands induce waterlogging and flooding on some 15 ha on the western side of the farm, damaging or interfering with summer trials in this area. To some extent, the demands of some program leaders for controlled screening facilities is linked to this problem. The improvement of this situation essentially depends on better maintenance of the external drainage system, a responsibility that lies with the Regional Irrigation Association.

The depletion of the water table may, on the other hand, cause problems of shortages of irrigation water during the dry season, a situation likely to worsen as the area in rice decreases in neighboring districts. This problem could be solved by boring deeper wells and utilizing adequate pumping equipment.

After having experienced a centralized labor pool system for manpower on the farm, and the many disadvantages associated with that system, the Center has now adopted a decentralized system by allocating each discipline or research area a permanent contingent of laborers (emergency reinforcements are also available). The system is obviously working to the satisfaction of all concerned.

While sufficient in number, and apparently adequate in performance, the agricultural equipment operating on the farm is generally old, particularly the tractors. Repairs and maintenance have become serious limiting factors during the field cropping seasons, and tractor repair requirements are exceeding the capabilities of the workshop. The Center purchased a new tractor in 1983, and the purchase of a second is a priority for 1984.

The Panel, in its visit to the experimental plots, was impressed with the level of care and maintenance that was evident, in spite of an environment that encourages weed growth. The plots were well cared for, and experimental error should be relatively low.
8. TRAINING PROGRAM

8.1 Objectives

AVRDC lists the objectives of the training program as:

(a) To train individuals and groups who will return to their countries to train others.

(b) To provide a cadre of well prepared and motivated research and extension personnel who will carry the responsibility of generating and teaching the vegetable technology necessary to improve yield and quality.

In addition to these general objectives, AVRDC has documented specific behavioral objectives for each component of training courses in vegetable production.

8.2 Organization

The Training Program is currently administered in conjunction with the Development Program. Both programs report to the Deputy Director General.

There are four main categories of training - research, production, special purpose and summer student. The following description of these categories is taken from AVRDC documentation.

The Research Training Program includes three types of participants: research interns, research scholars, and research fellows.

(a) Research interns are usually employed by research, commercial, extension, or educational organizations. Interns are expected to organize a research project relevant to the needs of vegetable farmers in their home countries, and, with the guidance of a senior AVRDC scientist, present their findings in the form of a final report. Interns are appointed for a period of five to six months.

(b) Research Scholars are candidates for masters, doctoral, or equivalent degrees at agricultural colleges or universities which permit students to do their thesis research under the supervision of a qualified scientist. The subject of the scholar's thesis is directly integrated with a research project conducted at the Center. Because AVRDC is neither located near nor affiliated with an agricultural university, scholars are expected to complete their coursework and qualify as a degree
candidate before arriving. The research project is a cooperative effort between the scholar, his/her advisor, the advisory committee of the scholar's home institution, and a senior scientist at AVRDC. Scholars are appointed for periods ranging from six to eighteen months, depending on the nature of their research.

(c) Research Fellows are usually researchers with recently conferred PhD degrees or experienced scientists with an MS or equivalent degree, who come to AVRDC to familiarize themselves with advanced research techniques and information regarding vegetable production and improvement. Fellows collaborate with senior AVRDC scientists in their field of specialization, undertake intensive research projects using facilities which may not be available in their home countries, acquaint themselves with new techniques currently being developed and adapted for vegetable production in the lowland tropics, and pursue other activities designed to advance their research potential and capabilities. Although shorter periods may be considered, fellows are usually appointed for one or two years.

The Vegetable Production Training Program is a five-month course designed to bring new knowledge and skills to extension agents, agricultural instructors, farm managers, and researchers. Although production trainees spend considerable time in the classroom learning the science of vegetable production, the concepts and techniques of applied research, the fundamentals of communication, and the economic factors involved in tropical vegetable production, emphasis is directed to field experience which allows students to apply that knowledge and to familiarize themselves with the crops, techniques, and systems studied in the classroom.

The Special Purpose Training Program is a flexible program for training individuals or groups with special interests or requirements. These programs may be either research or extension oriented, and may last from a few weeks to a year. Each special program is considered in reference to AVRDC's objectives, as well as the future role that the participant will have in agricultural development.

The Summer Student Training Program offers undergraduate students from agricultural colleges and universities the opportunity to gain practical research experience under the supervision of members of AVRDC's scientific staff. Summer trainees usually have completed their third year of study, and are appointed for a two-month term prior to their final year of study.
8.3 **Staff and Facilities**

Staff for the training (and development) program includes one principal officer, seven regular staff, and eight laborers. In addition, staff from the commodity and NEM programs assist in the training program as described above under "organization".

Dormitory facilities presently limit the number of trainees at AVRDC to about 30 at any given time.

8.4 **Achievements**

Approximately 500 individuals from 40 countries (87% from Asia) have completed training programs at AVRDC. Of these individuals, 20% received training in vegetable research techniques, 31% in production and extension, 17% in programs designed to find solutions to specific problems in their home countries, and 23% in undergraduate research and production.

8.5 **Constraints**

The major constraint of the training program is dormitory accommodation. While accommodation quality is satisfactory, there is only room for 30 trainees at one time. Staff availability and laboratory and field facilities do not appear to be limiting factors.

8.6 **Future Plans**

An Asian Working Group on Resource Allocation held in Singapore in 1982 summarized annual training needs in vegetable crops. The number of candidates to be trained per year was estimated at 218 in vegetable crop technology, and AVRDC was urged to meet these needs in terms of facilities, staff and scholarships.

A US $4.85 million training center has been designed to house 55 additional students. Classrooms/seminar rooms will accommodate about 90 persons, and a conference room will serve approximately 130 persons. A proposal has been submitted to potential donors but has not been accepted as yet. Construction should begin in 1986 or 1987.

An additional course will be considered for vegetable seed technology in 1986 to be carried out in association with the new genetic resources laboratory which will be functioning at that time. The Panel noted that an international course in vegetable seed technology and production was already available at the University of the Philippines at Los Banos.
8.7 Assessment and Recommendations

Experience at other IARCs has demonstrated that training programs are extremely important to the efficient testing and dissemination of the new technology. The review team was impressed with the importance attached to training at AVRDC and with the quality of the Center's programs, which compared more than favorably with those of other centers.

The training programs are well integrated with research. Both past and present trainees interviewed by the Panel commented favorably on the program, and it was evident, especially in the visits to outreach programs, that many former AVRDC's trainees had accepted posts in their home countries where they fully utilized the skills acquired in their training.

A strong feature of the production training courses, not always seen at other IARCs, is the emphasis given to linking research skills to on-farm application of new technology. A rationale for the present organization of the training and development programs is that on-farm testing of AVRDC germplasm and technology in Taiwan is integrated with the training program.

The Panel supports the proposal for the expansion of the present training facilities, while noting that the new capacity will meet only 40 per cent of potential annual demand for training at AVRDC. The Panel recommends that the Board attach high priority to this project.

The Panel observed that there was room for expanding the training program in Thailand. The Panel recommends that AVRDC evaluate the potential for increasing the number of training programs conducted outside of Taiwan.

The availability of AVRDC staff and requirements for equipment and facilities might limit the number of courses in other countries, but they could have potential benefits in terms of reaching larger numbers of trainees at less cost and with greater relevance to local environmental conditions. Such programs might also help to expand the familiarity of AVRDC scientists with conditions in cooperating countries.
9. THE TAIWAN DEVELOPMENT PROGRAM

9.1 Background and Objectives

The Taiwan Development Program was given its present name in 1979. It coordinates the activities of the Training, Communication, and Research Services Program. It passes improved germplasm from the commodity programs to the Development Program to evaluate it under farm conditions. It was emphasized that AVRDC should assist, and not by-pass or duplicate, the work of the national ROC organizations.

In 1981, it was made clear that the Taiwan Development Program had similar objectives and functions to the Center's Outreach Programs in Korea and the Philippines.

AVRDC currently lists the objectives of the Development Program as follows:

(a) To test AVRDC materials and cultural practices under Taiwan's varied physical and biological environments.

(b) To conduct studies in cooperation with local research institutes.

(c) To assist ROC national programs in demonstrating and extending to local farmers the new varieties and cultural practices developed by AVRDC.

(d) To assist AVRDC training scholars to learn small-scale farming operations and other appropriate technologies developed in Taiwan.

(e) To provide training at AVRDC for junior ROC scientists and college students.

9.2 Organization and Achievements

The Development Program is currently administered in conjunction with the Training Program, largely because the Development Program provides training opportunities to participants in AVRDC's vegetable production courses. Most of the following description of the program's organization and achievements is taken directly from AVRDC documents.

Under the Development Program, multi-location regional yield trials and adaptation trials are executed by the AVRDC Training and Development Office in cooperation with participating research institutes. Operating expenses, including those for trials conducted at AVRDC, are normally provided for by the Council for Agricultural Planning and Development.
(CAPD) and/or the Taiwan Provincial Department of Agriculture and Forestry (PDAF). AVRDC scientists visit the trial sites at appropriate times to perform field evaluations.

For special off-site experiments, such as insect and disease resistance screening, AVRDC scientists cooperate directly with participating stations, which generally provide free access to facilities and land. AVRDC is sometimes required to provide part or all of the operational expenses.

AVRDC provides free germplasm and lines to be tested for all trials.

Each year, AVRDC provides two to four junior vegetable researchers with scholarships to its training program. Candidates are recommended by the PDAF. AVRDC also conducts an eight-week summer training course each year for college students recommended by various universities in Taiwan. The students are assigned to individual scientists according to their field of study.

9.3 Planting Materials

Approximately 5,600 AVRDC accessions and breeding lines have been distributed to local research institutes during the past eight years. It is estimated that one-third of these materials are duplicates, especially those sent to different stations for seasonal evaluation in varied environments. Most were used in national breeding programs. The first heat tolerant and bacterial wilt resistant variety of fresh-market tomato, TSS-1, was developed from AVRDC materials by the Taiwan Seed Improvement and Propagation Station, and was officially released for commercial production in 1980.

9.4 Field Evaluation Trials

Since 1973, AVRDC has cooperated with local research institutes in conducting more than 150 field evaluation trials throughout Taiwan. These trials have facilitated the development of lines that are high yielding, pest and disease resistant, and adapted to an array of physical and biological environments. When sent to other tropical countries for testing, many of them performed better than local varieties, and have proven to be important sources of germplasm for national programs.

9.5 AVRDC Crop Releases in Taiwan

AVRDC-developed mungbean, soybean, Chinese cabbage, and processing tomato lines have been officially released for commercial production by the Taiwan Provincial Department of
Agriculture and Forestry. Although only one line of each crop has been released, each outyields the highest-yielding local varieties by 20 to 80%, and each is gradually replacing the older varieties.

9.6 Training

By the end of 1983, a total of 175 junior scientists and senior college students from Taiwan had been trained at AVRDC. Except for summer trainees, most came from research institutes for on-the-job training. Only five were from private companies. The special summer training program exposes the students to a real research environment before graduation. The program has interested students in AVRDC's research programs, and many of them have been employed by AVRDC after graduation.

9.7 Assessments and Recommendations

The Panel recognizes that the Taiwan Development Program is somewhat distinct from other AVRDC outreach programs for a number of reasons. First, Taiwan is the Center's host, and as such the Center enjoys special relationships, including generous funding provisions not expected from other national governments. Secondly, Taiwan's horticultural industries are highly developed in economic and technological terms, compared with other client countries. Thirdly, it is natural to expect that, for reasons of convenience, a large proportion of the initial testing of AVRDC germplasm and technologies will be done in Taiwan. For similar reasons, the Taiwan Development Program has special importance to the AVRDC Training Program.

Despite these distinctions, the Panel recommends that the Taiwan Development Program be re-named as the Taiwan Cooperative Program, largely to avoid confusion in terminology in the use of the word "development". The Panel takes the view that all cooperative/collaborative/outreach programs should be associated with the further development and adoption of AVRDC technology in client countries.

The Panel observed that although no formal agreement or Memorandum of Understanding has been made or signed with the Taiwan authorities, the AVRDC outreach objectives referred to earlier are being clearly achieved through a wide range of largely informal but effective collaborative activities and relationships. We found that these informal mechanisms are working well and recommend that they continue and be strengthened.

The most important areas covered by these collaborative activities include:
(a) The exchange of germplasm between AVRDC and national institutions especially in sweet potato and soybean.

(b) Varietal testing of materials from AVRDC along with others from national research programs in regional yield and adaptability trials, and district trials, which lead to the release of cultivars to farmers. The compliance of AVRDC with the Taiwan regulations and procedures in the area of varietal testing has facilitated the outreach work of the Center in the country, has generated a favorable atmosphere for cooperation, and should be highly commended.

(c) AVRDC and ROC breeders and agronomists have very close relationships in the development and testing of materials and the exchange of information.

(d) The ROC has benefitted from AVRDC's training program in the areas of research interns, scholars, production trainees, summer student trainees, and special purpose trainees. These trainees play important roles in AVRDC's outreach work in Taiwan because they are located throughout the network of the national research system. AVRDC also continues to benefit from the opportunity to expose trainees from other developing countries to the highly developed small farm technologies employed in Taiwan.

(e) AVRDC continues to play an important advisory role to various national institutions and committees in the use and adoption of criteria for the selection of materials for national testing and development. Such advice is based on its own research work on-site and on observations made from cooperative trials and tests throughout the country.

A number of issues were raised during the review of the outreach program in Taiwan. They include:

The Role of AVRDC in High Technology Vegetable Production

Taiwan, as a major vegetable producer and consumer has developed its production, handling, and processing relationships to such a high level that it is concentrating research on quality improvement in vegetables, processing prospects, and export expansion. There is concern that this is not a priority area for AVRDC given its commitment to improving the production and consumption of vegetables for improved food and nutrition among the
poor peoples of tropical countries. On the other hand, it is felt that, while AVRDC applied research in variety improvement from the productivity, adaptability, and pest and disease resistance points of view will continue to benefit many other countries, some attention to commodities such as processing tomatoes and other vegetable which generate cash income would be appropriate. In our opinion, AVRDC's research must continue to be beneficial to Taiwan farmers. In addition, AVRDC should continue to monitor the evolving situation in vegetable production and consumption in the region so as to enable it respond not only to the basic requirements of improved food and nutrition, but to improved income-earning capacity for the vegetable producing farmers.

The Panel recommends that AVRDC research and development continue to service the needs of vegetable farmers employing relatively highly developed technologies.

Postharvest Technology

Taiwan is concerned about postharvest technology research and applications in vegetable production. It was recognized that AVRDC has always had this as one of its areas for research and development, but has not had the resources to do the work. There is however a current AVRDC plan to initiate work in this area in collaboration with the Postharvest Institute for Perishable in Idaho, USA, and some preliminary surveys have been undertaken. Taiwan authorities have also sent 11 scientists for training in the area of post harvest technology, although the focus seems to be on mechanization, processing, and quality control for export. While these areas of Taiwan's interest may be outside those of AVRDC's immediate concern, we recommend that there be consultation between AVRDC, the CAPD, and other Taiwan institutions involved in postharvest technology, and that AVRDC attach priority to postharvest research and development from the biological and economic viewpoints, resources permitting.

Relevance of Taiwan Vegetable Production Systems to Other Client Countries

While recognizing the convenience of the Taiwan system for testing AVRDC germplasm and technology, it must be remembered that local economic and environmental conditions are distinctly different from those of most other client countries. The Panel recommends that AVRDC pay increased attention to the proper balance
between the level of local testing versus the testing done in cooperation with other client countries. Further, while supporting research and development in high technology vegetable production, the Panel recommends that heavy emphasis be given to successfully disseminating AVRDC improved germplasm and technology to countries where basic nutritional and economic needs are not being met for low income farmers and urban people.
10. OUTREACH PROGRAMS

10.1 AVRDC's outreach program began in 1973 with the initiation of the Korean Outreach Program, and was followed by the establishment of similar programs in the Philippines, Thailand, and Taiwan. Negotiations are presently taking place with respect to outreach programs in the West Indies and in Central America. While these are the countries with which AVRDC has, or will have, well developed programs, there is a larger constituency of about 100 countries which are testing AVRDC advanced lines for either release "as is" or for parental use in breeding programs. This larger constituency receives regular shipments of AVRDC germplasm and/or various nursery trials, but the countries do not make formal arrangements with AVRDC for technical assistance and training opportunities for their nationals, which is the hallmark of an outreach program. Even so, they can send candidates to AVRDC training courses, and in fact represent a very significant part of AVRDC's training clientele.

It should be indicated here that while AVRDC has various names for its formalized programs with cooperating countries, including such titles as National Cooperative, Collaborative, Development and Outreach, in general, there is some reason for the choice of a particular title for the program based on attitudes among officials of AVRDC's national partner - if they have no objection to outreach, that is the choice; if they prefer some other designation, AVRDC has no objection as long as the relationship promises to be productive. The generic term agreed to by the Panel is "cooperative", defined as a more or less formal arrangement, usually involving training and technology transfer promoted by an AVRDC staff member posted to the partner country for a relatively short time. It is, in fact, an arrangement which establishes in AVRDC's partner nation, a cadre of AVRDC-trained specialists who, for the indefinite future, are prepared to cooperate with AVRDC in the sense of receiving germplasm accessions and advanced lines for testing and screening in nurseries in which the AVRDC and other materials are compared with prevalent local cultivars. In addition, these efforts assist in the identification of potentially valuable germplasm.

The Review Panel examined the cooperative programs first hand in the Philippines, Thailand, and Taiwan. The Philippines Outreach Program (POP) was established in 1975 with funding from the Asian Development Bank (ADB), and did not involve technical assistance beyond relatively short-term consultancies, but concentrated on the introduction of AVRDC breeding materials and advanced lines,
and the training of production and research specialists. After the initial two-year ADB-financed period, funding for the program, primarily the salaries of Philippine cooperators and the cost of training at AVRDC, was assumed by the Government of the Philippines, and the program has, since that time, become an integral part of the Ministry of Agriculture, and has only fraternal arrangements for its continued cooperation with AVRDC. AVRDC's role in tropicalizing its mandate vegetables has been very successful as far as the Philippines are concerned; in '83 three AVRDC Chinese cabbage lines and one sweet potato accession were approved for release, and lines of tomato, mungbean, and soybean have been identified as superior in regional trials.

The Philippines program has demonstrated the efficacy with which new technology can be transferred through training specialists and exchanging germplasm, so that the outreach partner becomes an independent equal in the network. AVRDC staff travel to the Philippines to see the trials and to monitor the performance of their materials each year.

The AVRDC legume breeding programs offer a unique opportunity for broader impact through the UPLB/IRRI "Rice Based Screening Project for Legumes in Asia." This program provides the opportunity for AVRDC lines to be distributed and evaluated widely in conjunction with rice cropping systems. In particular the program provides a possible avenue for distribution of AVRDC soybean and mungbean stocks to mainland China.

10.2 Korea

The Korean Outreach Program is similarly mature, having had an AVRDC scientist stationed in Korea for only a few months after the ADB-funded two year project got under way. Close cooperation continues, based on frequent consultations between AVRDC staff, Korean specialists, and the cadre of AVRDC trained production and research staff serving in the program. In spite of the termination of ADB support in 1978, the Korean Sub-Center of the AVRDC carries on its operations under that name, in spite of being completely integrated into the Korean Office of Rural Development. The program has been very successful, and has released several AVRDC-based varieties, including two mungbean varieties, three Chinese cabbage hybrids varieties (which permit production in lowland areas in summer), one variety of tomato for processing and four soybean varieties. The Korean program uses AVRDC fields to grow winter generations of soybean breeding materials, as well as growing and bulking segregating populations (up to F5) before taking them back to Korea for selection.
10.3 Thailand

The Thailand Outreach Program (TOP), which was finalized in 1975 but not activated until 1981 due to "political constraints", is flourishing, and is in its second phase, financed by ADB and by the Federal Republic of Germany (for training) for a three-year period (1983-85). An AVRDC scientist is posted in Thailand, and is expected to be involved there for several years. The project, involving the Ministry of Agriculture as AVRDC's counterpart agency, operates with the Ministry's role being delegated to Kasetsart University. The University has made experimental fields available not only for trials, but for trainees, including trainees those from outside of Thailand. The program goes well, with involvement not only from Kasetsart, but also from the Universities at Chiang Mai, Khon Kaen, and Songkhla where horticulturists are selecting varieties from AVRDC nurseries.

Training is a very important part of the TOP program, and one five-month training course has already been held, with a number of trainees from outside of Thailand in attendance - trainees who would not have been able to attend at AVRDC headquarters.

The excellent training facilities at Kasetsart University have been a factor in the informal arrangement with Thailand by which AVRDC extends in Thailand the opportunities for AVRDC training and scientific interchange to those that cannot attend at Shanhua. AVRDC, the panel was informed, is very pleased that the Thailand Outreach Program can apparently function as a relay station for exchanges between the Center and several countries in the region, e.g. Bangladesh, Burma, China, Nepal, Pakistan, and Sri Lanka. Contacts have been made with the major countries of the region involving training, material exchange, and scientific cooperation. Activities have included the distribution and field assessment of AVRDC germplasm and the demonstration of field and laboratory techniques for the identification, prevention, and control of plant diseases in several crops. In visits to various institutions, AVRDC staff has been involved in symposia, workshops, field surveys, and lectures in an exchange of information with scientists in the region.

The Panel was very pleased to learn that both the official and unofficial positions of the Thai Government and Kasetsart University were that trainees and horticultural research personnel from countries other than Thailand were welcomed at TOP training courses and at workshops and other forms of scientific interchange.
10.3 Taiwan

The Taiwan Development Program is a special outreach operation. It is obvious, for instance, that if AVRDC technology is going to be acceptable anywhere, it must prove that it works in Taiwan - As a consequence, Taiwan must be considered as a kind of field laboratory for the validation of AVRDC materials and techniques.

The Provincial Department of Agriculture and Forestry has a well organized system of Regional and District yield trials for testing candidates for release as licensed varieties. These trials are managed by the various District Agricultural Improvement Stations (DAIS), each of which acts as coordinator for a particular crop (or crops) which gives AVRDC a relationship with the scientific staff of the individual DAIS's handling the testing system for the individual mandate crop. The important part of this system, from the AVRDC point of view, is that the trials are laid out in farmers' fields, and the care and management of the trials are that responsibility of the farmer himself, and, therefore, success in these trials is a validation of the technology under farm conditions.

While farm conditions in Taiwan are perhaps at a higher technical and management level than in other countries, it has been pointed out to the Panel members that the evolution from small subsistence farmer to small commercial farmer is a common factor of agricultural development in all countries, and that Taiwan management levels of today are the management levels of tomorrow (and not the distant future) of other societies. It is accepted, naturally, that the package of technology, particularly the definition of appropriate cultural practices, will be different in different environments, and must therefore be defined anew for each environment that the technology moves to. This is the responsibility of the team in each country and cannot be an AVRDC headquarters responsibility.

In AVRDC nomenclature, the Taiwan outreach program is called the Taiwan Development Program, justified in part, because of the role that the farm testing of advanced lines plays in the development of AVRDC's breeding programs and the evaluation of the cultural practices package. Other aspects of the Development program which are of benefit to both AVRDC and to the Provincial Department of Agriculture and Forestry (and other ROC institutions) is the interactions between scientists working on the same crops, service on the same committees, participation in seminars and scientific meetings, etc. For the sake of uniformity, the Panel suggests that the Taiwan program be renamed the Taiwan Cooperative Program.
It is remarkable that in the period of AVRDC's involvement with Taiwan, it has not been necessary to formalize the arrangements with a signed agreement or Memorandum of Understanding. The ROC Government pays the direct costs for AVRDC's services in general, with the exception of some scholarships, particularly those for summer students which are financed out of AVRDC's core budget (to which the ROC is the largest contributor).

10.4 New Programs

Additional cooperative programs are taking shape, and arrangements are expected to be finalized for major programs in Malaysia and Indonesia, both to be financed for two years by ADB at a level of more than US $200,000 each.

Other requests are being negotiated, but are not quite so advanced; one for the West Indies (based in St. Lucia) to be funded by USAID, and another for a regional program in Central America to be financed by the countries involved, with assistance from bilateral and multilateral donors.

In considering different aspects of the cooperative program, various points have been discussed by the review team. Some of these are discussed below.

In the outreach programs examined, it appeared that more back up and support by headquarters personnel would be a valuable addition, not only in being part of the monitoring team for the trails being conducted, but also to increase the amount of interaction and interchange with local scientists. The absence of raised beds for tomatoes in land subject to flooding was a factor in the poor performance of some test material in the Philippines; more supporting visits for consultations might have assisted in the transfer of the cultural practices packet as well as in the transfer of new germplasm. The Panel is fully aware of the shortage of both travel funds and staff time, but suggests that additional headquarters staff travel to outreach programs (particularly those which no longer involve AVRDC staff posted permanently outside of headquarters), would have great benefits with respect to integration of the outreach work into national programs and increased interactions with the local scientists. This kind of travel, and additional funds for attendance at national and international professional and scientific conferences, must wait until funding is available and scientific staff numbers are increased.

In a similar vein, it is difficult for many national scientists to learn what is going on in even neighboring countries...
because of difficulties in financing travel. The panel is aware of certain monitoring tours organized in connection with international regional programs for testing advanced lines of field crops against standard varieties. If and when funds are available for AVRDC to finance such monitoring tours for vegetable crops, these might become part of the network activities, visiting perhaps four countries each year (but not always the same four) so that the participants in international nursery trials can learn what is going on in other countries. The Panel is confident that the effects on the national scientists would be some of the best training possible.

Workshops and seminars have been an important part of both the training and outreach programs. AVRDC's policy of holding such meetings in various countries involved in the outreach program is considered to be very useful in enlarging the Center's sphere of influence.
11. RESEARCH ORGANIZATION AND MANAGEMENT

11.1 General Observations

Research on vegetables is the primary activity of AVRDC. In large measure, the way in which the research activities of the Center are managed and executed determines the institution's success in achieving its overall mission. Because both the physical and personnel resources of AVRDC are limited, and must be divided among the five mandate crops, the management of these resources in the execution of research must be a matter of the highest priority.

11.2 Research Organization

AVRDC research is organized into three major programs: Legume crops, Horticultural crops, and Nutrition, Environment and Management. Each is led by a Program Leader who provides the primary administrative link between individual scientists and the Director General/Deputy Director General. The Program Leader is responsible for evaluating, assembling, and presenting the budgetary requests of the scientists in his program to the Director General/Deputy Director General for the annual budget review and allocation.

Within each program, Commodity Coordinators designated for each crop are responsible for providing leadership in research planning and coordination among the scientists. The Commodity Coordinators are the key link between individual scientists and the Program Leaders. Senior scientists, representing the specialized disciplines involved, such as plant breeding, pathology, entomology, physiology, soil microbiology, chemistry, soil science, crop management and economics, constitute the Commodity Group, which focuses research on each specific crop, based on agreed objectives and priorities. Each senior scientist is supported by research assistants, and is provided with equipment, land, supplies and labor to support his/her activities.

At the end of the budget exercise, each senior scientist will have received a budget allocation for the running expenses for each of the crops he or she will be working on, that allocation being the result of tentative program budgets being divided first on a commodity basis, and within the commodity group into allocations required for the services the commodity group agrees should be the responsibility of the discipline involved. A commodity group agreeing on tasks for five scientific disciplines will split the commodity budget accordingly.
11.3 Research Planning

Research planning is problem-oriented along commodity lines. The research planning process formally begins when small groups of scientists meet with a crop coordinator for discussions of specific research problems in what are known as Crop Commodity Council meetings. The Council meetings are held twice a year to review in-depth research results and to plan experiments. The meetings are attended by participating scientists, their research assistants, and the Directors General. It is as a result of the Commodity Council meetings that senior scientists determine the degree of their involvement in particular projects, and allocate their time and receive budget allocations. The Crop Commodity Councils and the Council meetings are vital parts of the Center's interdisciplinary research planning and coordination.

Within each commodity, research plans are structured on a carefully developed set of general and specific objectives which are justified on the basis of a brief written narrative. Strategies for approaching specific objectives are developed as specific working plans which are approved for implementation based on a priority ranking.

Budgetary needs and constraints involved with the specific objectives are part of the working plan. Research reports are submitted annually to the crop coordinators by each of the senior scientists. From time to time, scientists present seminars to the entire scientific staff.

Annual evaluations of research assistants and laborers by the supervising scientists are submitted to the Director General/Deputy Director General via the Program Leaders.

11.4 Assessment and Recommendations-General Comments

The organization of research via crop oriented programs provides an effective structure for the identification of specific objectives and the execution of research within the mandate of AVRDC. The degree to which each of the specialized disciplines understands its roles and focuses its respective expertise on the solution of both the general and specific objectives of a commodity will, in large measure, determine the success of the crop program. Both the legume and the horticultural commodity groups have been able to focus their specific objectives; however because of the limited number of senior specialists within each discipline, each scientist must select his/her particular inputs to a specific crop with great care so as not to dilute his/her efforts to the point of being ineffective within the program. The Panel feels that judgments as to how best to partition
one's time and research efforts are critical to the success of each group's objectives and must lie with the commodity councils.

The small number of senior staff at AVRDC and the excellent living and working environment has led to an intimacy and esprit de corps among the scientists that can be of great benefit to communications, and at the same time, be a deterrent to frank and candid evaluation of collegial research. Commodity team members, Crop Coordinators, Project Leaders and the Director General/Deputy Director General must be particularly sensitive to this issue in attempting to assist their colleagues in formulating research objectives and working plans, and in the allocation of budget resources so that they maintain the appropriate focus to the general and specific objectives of the crop or project. Particular attention should be given to the thorough introduction of new senior scientists and visiting scientists to the need to operate as effective commodity-oriented team members.

Under the present conditions, with a limited number of senior scientists and research projects focused primarily through the Commodity Groups the functioning of the Director General/Deputy Director General essentially as "directors of research" is appropriate and workable. If the numbers of research projects and senior scientists were to increase significantly the roles of the Director General/Deputy Director General in research management would have to be carefully reassessed with the object of determining when a Director of Research already suggested by senior management, should be added to the system.

The Panel found a diversity of activities within the Nutrition Environment and Management (NEM) Program, that virtually precluded the development of a common set of objectives upon which research could be coordinated (see review chapter on NEM). As a consequence, the panel recommends the restructuring of the organizational plan for research management, perhaps involving some variation of the formula given as an example in Figure 1. By removing from the existing NEM program all of those activities which represent research service or research resource oriented functions into a new unit entitled Central Resources and Services, the existing crop nutrition environment and management activities would remain under a restructured Production Systems Program. Included in the Production Systems Program would be 1) soil, water and fertility management, 2) crop management including, spacing, timing, and pest management, 3) cropping systems, 4) production economics and marketing and 5) post harvest technology. Included in
the Central Resources and Services program would be 1) statistical and computing services 2) chemical analysis, including biochemical, soil and pesticide analysis and 3) germplasm resources and seed laboratory.

Although it is implied in the title that the Central Resources and Services unit would provide services and resources to other programs, it would be expected that the activities of the senior scientists in this unit would be actively engaged in research projects required for their particular disciplines, as well as directly collaborating in the research of other programs and disciplines.
Proposed Management System of AVRDC Research Programs

Director General
   Deputy
   Director General

Legume Program (Leader)
   Plant Breeding
   Plant Pathology
   Entomology
   Plant Physiology
   Soil Microbiology

Horticultural Crops Program (Leader)
   Plant Breeding
   Plant Pathology
   Entomology
   Plant Physiology

Central Resources & Services (Leader)
   Statistics and Biometrics
   Chemical Analysis
   Biochem, Soil, Pesticide
   Germplasm Resources and Seed Laboratory

Production System Program (Leader)
   Soil, Water, & Fertility Management
   Crop Management
   Pests, Spacing, Timing
   Cropping Systems
   Production Economics and Marketing
   Postharvest Technology
   Soil Microbiology

Soybean Commodity Committee (Coordinator)
Mungbean Commodity Committee (Coordinator)
Tomato Commodity Committee (Coordinator)
Chinese Cabbage Commodity Committee (Coordinator)
Sweet Potato Commodity Committee (Coordinator)
12. ADMINISTRATIVE AND FINANCIAL MANAGEMENT

12.1 AVRDC's research organization and management, and more specifically its functioning in terms of discharging the Center's mandated responsibilities, are covered in another section. In this chapter, administration, finance and associated procedures of the Center are discussed.

This review was not designed to provide an in-depth examination of each component of the Center's management. It should be remembered that such in-depth analyses and assessments, within the CGIAR System, are now specifically organized as management reviews, commissioned separately from, but simultaneously with the external program reviews. The management review teams consist of two to four consultants who spend at least two weeks examining the management systems of the international centers.

In order to evaluate the management, administration, personnel policies, and finances of AVRDC, the full Panel devoted two sessions to these matters. A consultation session with the regular staff was conducted by three of the members. In addition, the Chairman and Secretary met successively with the Director General and his immediate collaborators as a group and on an individual basis with their staffs.

12.2 Board of Directors

It is clear from AVRDC's Charter and By-Laws that responsibility for program formulation and implementation rests with the Director and Deputy Director Generals of the Center. The Board has the power and duty to formulate policies guiding the program, to review and approve the program and budget submitted by the Director General, and to concurrently monitor the progress of the Center and its finances.

The Panel gives full support to the actions which the Board has taken in order to discharge its responsibilities, and to the way that it achieves an understanding of the activities and problems of AVRDC.

Taking into account the future evolution of AVRDC vis-a-vis the system of international agricultural research and the possible association of the Center within the context of this system, the Panel considers it as being in AVRDC's interest to adopt and apply as closely as possible the Board procedures followed by other IARC's. In doing so, the Center will further enhance the confidence which the donors have in the quality and efficiency of its activities.
AVRDC has many similarities to and some differences from other IARC's. These issues are discussed below.

It is stated in the AVRDC Charter that the membership of the Board of Directors will consist of representatives of the participating countries (i.e. financial donors), and for some years the Board was limited to such an arrangement. Fortunately, the participating countries have almost always named qualified agricultural scientists so that the Board could discuss the scientific merits of the proposals that they dealt with. It should be noted that most IARC's do not have members on their boards named by donor countries, primarily, one suspects, to avoid national and other kinds of political bias. IARC boards elect members from nominations that come to it largely from their own ranks. The nominees tend to be technically qualified people who represent, at least in part, the regions in which the IARC is involved.

AVRDC has not limited membership on its Board to representatives named by participating governments, and by resolution has approved the addition of up to eight Board members named by the Board itself. At the present time, the national representatives are outnumbered by those Board members who do not represent participating countries.

The Board names its own Chairman and Vice-Chairman from its members. They are elected by acclamation, only one being nominated. The Chairman and Vice Chairman serve two year terms and may be re-elected without limits on the number of terms that they serve.

The national representatives serve on the Board at the pleasure of their Governments, and are otherwise not limited to a specific term of service. Board-elected members serve four-year terms and are not eligible for re-election.

AVRDC's Board, according to the Board meeting minutes, serves the Center well, and is scientifically well qualified to make policy and program decisions. The Review Panel sees no need to suggest changes in the Board's membership. It does, however, feel that, in spite of the sterling service of the two Board Chairmen (and two Vice Chairmen) who have filled the position since AVRDC began, that there is a potential source of trouble in not having a limit on the number of times that the Chairman can be re-elected. The Review Panel recommends that the Board examine the merits of limiting the period of service of the Chairman to perhaps four or six years (i.e. re-elected once or twice). This recommendation should not be interpreted as putting any limitations on the term of service of the present Chairman, who continues to serve AVRDC well.
The Board normally meets once a year for two days. There have been suggestions that three-day meetings would provide more time for the consideration of complex subjects which sometimes are referred to an ad hoc Committee to report to the Board the following year. This naturally leads to delays in the decision making process.

The Review Panel understands that the Executive Committee of the Board, which was recently constituted, does not normally have the authority to act on behalf of the Board between meetings. If called upon by the Director-General to deal with an emergency, it is limited to giving advice, making recommendations, and recommending full Board approval at the next meeting. The Review Panel suggests that an Executive Committee, composed of the Chairman, or in his absence, the Vice Chairman, the Director General and two other members of the Board, be given power to act on behalf of the Board whenever decisions must be taken prior to the next Board meeting, the quorum for the Executive Committee being three. The Panel can see real advantages for the Board, which can delegate to such an Executive Committee decisions which should not wait until the next Board meeting, e.g. the approval of additional budget items as the financial situation is clarified during the year. The existence of such a Committee, with authority to hire and fire when necessary, could provide valuable Board support to the Director-General with such advice, assistance and decisions as are necessary in emergencies or situations requiring rapid action.

The Program Committee of the Board is much more important to the long-term development of the Center than is the Executive Committee. The Program Committee should be composed of competent scientific specialists who can appraise research programs and then report to the Board (primarily, the donors). The problem, as the Panel sees it, is how to arrange the Program Committee meetings and at the same time avoid interrupting on-going research. It would appear inappropriate to have the Program Committee present at the Center's annual Progress and Planning Workshop when past results and future programs are being evaluated, since that would interfere with frank interchanges between the scientific staff. The Panel suggests that Program Leaders and their staff report on past progress and proposed programs to the Program Committee immediately before (i.e. two days before) the annual Board meeting so that the Program Committee can report to the Board, and if necessary, have the benefit of the reaction of the Director-General and his staff. This could mean that since the review of last season's work, and planning for the coming season, depends on harvest dates plus time for analysis, the Board meetings
might have to be scheduled after the crop committees have completed their deliberations and have at least conditionally finalized their work program. As part of the Program Committee's review, time should be made available to see the field plots.

In reading the minutes of the Board meetings, it is obvious that the financial management of the Center, and the provision of adequate financing are the Board members' main concerns. Two aspects of this matter have concerned the Review Panel: 1) the difficulty of giving adequate attention to income and budgets during a short two day meeting, even when the reports are distributed well in advance of the meeting and 2) the problem of the Board being able to give adequate attention to the external auditor's report and to have adequate face to face discussions with the external auditor on the points he raises. The Review Panel suggests that the Board consider the advisability of establishing a two-man Finance and Audit Committee which would report to the Board on financial matters, including expected income and budget proposals. This committee would also report to the Board with respect to the external auditor's report after interviewing the auditor.

12.3 Director General's Staff - Organization Structure

The Director General's staff consists of the Deputy Director General, the Director of Administration, and the Comptroller. Prior to 1980 there were two Associate Directors, one for research and the other for administration of local staff and in-country relationships.

Besides the managerial responsibilities usually attached to his function, the Director General also negotiates for and administers the Center's cooperative programs.

Among various well defined coordination, liaison, and supervision responsibilities, and besides his function of assisting the Director General, the assignments of the Deputy Director General include an active and supervisory role in relationships with institutions in the host country.

Responsibilities for the direction of AVRDC research and training are shared by the Director General and the Deputy Director General. Both are concerned with day to day problems involving the direction of research and training, primarily because they control the contingency budget.

The Panel recognizes the advantages, and particularly the flexibility that such an arrangement provides, benefitting as it does from the nature of the relationship between the two personalities involved.
The duties of both the Director of Administration and the Comptroller are clearly stated.

The Panel has noted the good liaison existing at the level of Director General's Office, and the quality of their functional actions as a well integrated "Command Unit".

The Panel recognizes that the growth of research and outreach activities of AVRDC, which is expected to occur in the relatively near future, may justify a re-distribution of responsibilities by creating, as foreseen by the Directors General, the establishment of two directors in charge of research and outreach activities, respectively. The Panel does not, however, consider the appointment of the first of these positions as an urgent necessity under current conditions. As to the latter, new agreements likely to be concluded by AVRDC in various countries may justify its creation somewhat sooner.

Both options mentioned above are discussed in other sections of this report. In preparation for the time when program development at AVRDC will justify their implementation, the Center's Directorate has started considering modifications of its organizational structure in the light of the proposal to create these two new positions. Although the Review Panel has deemed it necessary to express its views in the preceding chapter on the operational structure of the research programs in relation to the support services and discipline areas, it does not think it appropriate to formulate any advice on the place of these new positions within the organizational chart and on their links with existing decision levels. Rather, the Panel considers it appropriate to leave it to the Center's management to adopt adequate solutions in due time, knowing that much will depend on the aptitudes of the senior staff concerned when selecting among diverse alternatives.

12.4 Personnel Management

A clear and complete analysis of personnel management at AVRDC has been presented to the Review Panel. The Panel has noted that a number of steps have been taken during recent years for improving the situation in the following ways:

(a) Conditions of employment are duly categorized, defined, and standardized. AVRDC has established or consolidated compilations of its policies of employment for professional as well as regular staff.
(b) Emphasis during the last two years has been placed on salary schedules and staff incentives.

(c) Research assistant salaries were increased by about 30% in 1980 and substantially each year thereafter until 1982; AVRDC now provides a salary and benefits package competitive with local agricultural institutions.

(d) Salaries of internationally recruited staff have likewise been improved since 1981, although they are still significantly lower, in terms of averages, than those of scientists at other IARC's (similar benefits are being offered through IIE contracts).

The Panel received indications from staff members—both senior and junior—that the salary levels are not nowadays a major subject of complaint. Considering the recognition by the senior staff themselves that the environment in Taiwan compensates to some extent for somewhat lower salaries as compared with their counterparts at the CG Centers, the Panel concurs with the objective of the management, with respect to salaries, to gradually increase to a level of about 80% of the average salaries at other IARC's.

All grades of staff are evaluated annually according to methods ensuring uniformity in the evaluation of personnel in various disciplines and responsibilities. Standard evaluation forms are normally used for the regular staff. Less formal in character, the procedure of performance evaluation of the senior staff seems likewise to be applied with rigor and equity, involving assessments from superiors and senior management.

Deficiencies in work performance are expected to be discussed with the staff concerned. While not totally exempt from criticisms expressed by some of the personnel (inevitable to some extent), the rating system utilized at AVRDC has been endorsed by the Review Team. The Panel encourages the management to maintain and increase the spirit of fairness and justice on which the system is based.

Promotion and salary increases are highly dependent on annual staff evaluation and on the recommendation of supervisors who supply additional information on the employees under their supervision.

The Review Panel endorses the Center's policy of linking incentives to performance, and encourages the maintenance of objectivity in the promotion procedures.

Opportunities exist at the senior level for staff development through sabbatical leave and study leave. A policy has been
Designed to provide scholarships for locally recruited research and training staff who wish to undertake MS programs in local universities. Each scholarship comprises leave without pay, provision of tuition and fees required by the universities, and a monthly stipend (NT$10,000).

Turnover in professional personnel appears to be quite normal. Junior staff, on the contrary, has shown a relatively high rate of turnover, although significantly reduced as compared with what it was a few years ago. It must be said, however, that the reasons for this situation are to some extent outside the control of the AVRDC management. The Review Panel has noted that the Center's management has worked, and continues to work, on problems related to the regular staff situation, and has already improved the situation considerably. Based on the consultation held with the regular staff by three team members, and having properly balanced the comments and requests expressed during that session, the Panel thinks that some additional interaction should be arranged to enhance the feeling of satisfaction among this group. Improvement in professional relationships between senior and junior staff within discipline areas and across programs should be considered in this respect. The Panel recommends that initiative be taken at the professional staff level in order to develop better intellectual involvement and participation with the regular staff in the planning and implementation of research work.

Although systematically organized at the Center, existing communication procedures may present some deficiencies which need to be identified. The Review Panel recommends that, in so far as the regular staff is concerned, the existing communication mechanisms be reviewed and that a process be institutionalized for a regular dialogue between management and this group of staff members. Similarly, a procedure should similarly be designed so that personnel at the lower levels have the privilege of dialogue on a regular and periodic basis with the supervisors and section heads in their work units concerning policies and activities in which they are involved.

As in the case of the personnel program, AVRDC has in operation revised salary schedules and staff development opportunities through advanced study or special professional travel. Budgetary constraints limit the implementation of the Center's well understood philosophy regarding post-doctorate appointments.

The Panel does not believe it has to emphasize the loss of opportunities that these limitations bring to the Center in
terms of research potential, development of working relationships, and impact. It thinks it necessary, however, to encourage the adoption and implementation of measures that will further post-doctorate appointments, preferably focused on specific core program interests, or aimed at filling recognized program deficiencies or areas of study that can be dealt with through relatively short appointments.

12.5 Financial Procedures and Operations

From the description which the Panel was given, AVRDC's financial procedures and control systems appear to be both simple and efficient, and offer guarantees of rigour and safety.

12.6 Budgeting and Control of Expenditures

Each October, the Directors General assemble with the Program Leaders and department heads to discuss and decide budgetary allocations for the next exercise. After the budget review has been completed, the Director General issues an annual expenditure budget to each program/department. All purchases (except for amounts under NT$1500) must be approved by the appropriate Program Leader and the Director General's Office before being handled by the office of the Director of Administration.

AVRDC has adopted a centralized system for controlling all payments. Monthly expenditures statements are prepared and sent to each Program/Department for information and budget control.

Although the financial situation of AVRDC has improved during the past few years, some uncertainties remain at the start of each fiscal year due to lack of definite knowledge regarding the amount and time of final contributions of some donors. The system presently in operation, however, reduces the inconvenience of this situation to a minimum, and the research activities do not suffer excessively. Due to the funding constraints, capital requirements have been deferred until just recently, priority being given to scientific needs and to the replacement of equipment. Any necessary equipment replacement or new equipment is listed on an agreed priority basis by scientists and the Director General and purchased, if possible, at the end of the budget year when the income figures for the year are known.

Banking arrangements, currency and cash management, and the adequacy of investment policies have all been presented to the Panel, and call for no particular observation, except that it would be appropriate that AVRDC's Board of Direc-
tors issue formal statements regarding the Center's investment policy, and authorize, when necessary, the temporary use of funds in reserve accounts available to the Center.

12.7 Quality and Scope of External Audits

Since the first audit sponsored by AID in 1973, T. N. Soong Auditors have conducted annual audits of AVRDC financial reports. Financial audits require a one month residency by two experts for reviewing and auditing books and documents. This generally takes place in March. When completed, audit reports are submitted along with AVRDC Financial Statements to the Board of Directors. The Director General's Office reviews the Center's management frequently and makes necessary adjustments throughout the year.

As already mentioned, the Review Panel suggests that, annually, at the occasion of one of their meetings, effective interaction could take place between the Board of Directors or its Executive Committee (or, when created, its Audit Committee) and the external auditor. The Board should also address itself to the question of a possible change or rotation of the firm engaged for the audit of AVRDC.

12.8 Internal Audit - Internal Check

The size of AVRDC and the degree of complexity of the Center's operation do not justify the establishment of an independent internal control and audit department to perform the functions of an internal auditor. The current internal control system appears to be suitable, disbursements and supporting documents being checked by supervisory staff in research, administration and the Comptroller before disbursement. Likewise, the existing mechanisms of administrative and accounting procedures, controls of inventory of equipment, and the use of supplies and expendable items appears to operate efficiently.

12.9 Reporting from Off-Campus Stations

Cooperative project funds are controlled by the Center and allocated, according to requirements estimated by the resident scientists, after the Director General's approval. The Comptroller's Office uses normal expenditure and accounting procedures. Project funds are deposited in a U.S. bank and U.S. dollars are converted to local currencies based on local need.

12.10 Administrative and Logistic Support Functions

Besides the accounting and budget offices placed under the authority of the Center's Comptroller, the supporting
departments of AVRDC include the following services: Buildings and Maintenance, Personnel, Food and Dormitory Services, Purchasing, Shipping, and Security. These services fall under the Director of Administration. The overall presentation of this set of supporting administrative services allowed the Panel to appreciate the steps taken by the Center, as a result of the persistent financial shortages that it was dealing with, to reduce its costs of operation and to achieve significant savings by appropriate management practices.

AVRDC’s administrative and financial structure appears to combine, with all necessary accountability, a relatively centralized operation and chain of command with a fairly simple financial system.

The Review Panel commends the Directors General and their collaborators for having managed to maintain a proper balance between supporting management and the main thrusts of the Center in order to preserve the research functions of the crop programs.
13. FUTURE PLANS

13.1 AVRDC has been in existence for over 13 years. During this period it has built a reputation for highly focused work of commendable scientific quality. In preparation for this External Review, the management and staff of the Center have given considerable thought to the prospects for development and their future strategy and plans. The current thinking of the Center on future strategy and plans are presented in the document entitled "AVRDC Organization and Plans" and in "A Five-Year Plan for AVRDC, 1986-1990." These documents represent an in-depth analysis of the problems, prospects, and achievements in vegetable research, and provide a well-reasoned strategy and plan for greater achievements by AVRDC in the future. The Panel was impressed by the quality of the assessment and the realism and farsightedness of the plan.

The strategy and plan provide for a healthy evolution of the existing commodity research efforts and of programs that would bring the benefits of AVRDC research to national, regional, and other international programs through the distribution of improved materials, dissemination of research results and recommendations, collaborative research, and through training.

13.2 Research and Development Programs

The strategy and plans with respect to the Center’s mandate crops, training, and outreach are outlined and commented upon as follows.

13.2.1 Soybean

AVRDC proposes to intensify research work on soybean as a vegetable protein source for the tropics. The focus will continue to be wide adaptation, high yield, pest and disease resistance, and efficient utilization of naturally-occurring Rhizobia. Some attention will also be paid to the strengthening of current work on the development of vegetable soybean.

The Panel in recognizing the present and potential importance of soybean in tropical Asia, fully supports the plan. It notes the useful collaboration that has already been initiated with INTSOY in soil microbiology and international testing, and urges that cooperation with other international centers working on soybean (e.g. IITA) should be initiated or strengthened.
13.2.2 Mungbean

The Center proposes to continue the development of higher and more stable yielding mungbean with multiple resistance to major diseases and insect pests, including viruses. Attempts will be made to combine the desirable genetic traits of black gram (Vigna mungo) and rice bean (Vigna umbellata) with those in mungbean through interspecific hybridization. It is anticipated that sufficient progress, except for interspecific hybridization will be made in three to five years, after which the scale of the breeding program could be reduced.

The Panel endorses the proposal to continue the research efforts in mungbean in view of the potential contribution of this crop to food and nutrition in tropical Asia. It agrees that the program could be phased down after three to five years, with provisions being made to transfer the new mungbean technology to client countries. The Panel recommends that any additional work of major significance on legumes should be undertaken after a detailed consideration of the criteria for the selection of additional crops.

13.2.3 Chinese cabbage

Following the development and wide scale testing of hybrid and open pollinated Chinese cabbage lines, which is expected to be concluded in 1985, the Chinese cabbage program proposes to shift emphasis to the training of developing countries' personnel in hybrid and open pollinated seed production. It is also proposed to initiate work on the development of heat tolerance in another Brassica.

The Panel supports this proposal and urges that careful consideration be given to the potential contribution to food and nutrition for tropical peoples in selecting any new Brassica species to be worked upon.

13.2.4 Tomato

AVRDC has successfully developed heat tolerant and bacterial wilt resistant tomato for the tropics. In the future it is proposed to continue with the improvement of the tropical tomato both as fresh fruit and processed vegetable, and to develop heat tolerance and resistance to major diseases.

The Panel recognizes that more research is required on the tropical tomato and endorses the proposal to develop more lines for the lowland humid tropics and extend evaluation trials to Africa and tropical America.
13.2.5 **Sweet Potato**

AVRDC has achieved significant improvements in the yield and nutritional quality of sweet potato. Future plans intend to focus on the improvement of the distribution of virus-free improved materials using tissue culture and reliable international virus indexing techniques. In the event that these measures fail to stimulate national programs to undertake the use and improvement of these materials in their own programs, AVRDC proposes to reduce its future work to only germplasm characterization and maintenance.

The Panel reinforces its support for the plans to ensure the delivery of virus-free materials and cultivars to national programs and endorses the position that AVRDC has taken with respect to its future responsibility in sweet potato research.

13.2.6 **New Vegetable Research**

AVRDC proposes to select new vegetable crops for inclusion in the future, especially after the termination or reduction of the level of research on some of the current mandate crops. The Panel commends the preliminary study already undertaken at the Center which produced the proposal for the adaptability study for new crops. It urges that careful consideration be given to the criteria of contributions to food and nutrition in the final selection of new vegetables as mandate crops.

It is obvious that AVRDC will have to make some hard choices with regard to new mandate crops and new areas of research in the future. These choices are expected to be hard, in view of the fact that there are many potential candidates, and that there will, among other things, be the need to emphasize those vegetables that have the potential to contribute more effectively to food and nutrition among the poorer peoples of the tropics. In making these decisions it would be necessary for the Center to maintain a realistic view of its growth possibilities, to ensure the maintenance of reasonable efforts and attention on the current mandate crops and their germplasm, and to provide for flexible levels of support for programs as required.

13.2.7 **Germplasm**

The Panel supports future plans to expand and develop the Genetic Resources Unit as a major resource for AVRDC's research on vegetables. It is hoped that adequate support will be secured to enable the unit to undertake its full
The plan of activities in collection, research, preservation, and characterization of accessions. The Panel endorses the proposal to develop further the tissue culture activities to ensure the maintenance and distribution of disease-free materials to national programs.

13.2.8 Nutrition, Environment, and Management

The plans to have NEM continue in its present form has not received the support of the Panel. Rather, the Panel has suggested that the Central Services functions be separated from it and that it be constituted into a Production Systems Program. Details are presented in the sections on NEM and on Research Organization and Management.

13.2.9 Postharvest Technology

Postharvest technology research has always remained an area of interest to AVRDC. The Panel recognizes that AVRDC could play a useful role in this area by researching the development and adoption of appropriate postharvest technologies at the production, handling, packing, and primary processing levels. However, the Panel endorses the contact that has been initiated with the Postharvest Institute for Perishables (PIP) of the University of Idaho, USA, with a view to studying and defining the postharvest technology program that AVRDC and PIP might collaborate on. The Panel warns that great care should be taken by AVRDC to avoid being drawn into inappropriate activities that could direct its attention from its primary focus of improving the quality and yield of vegetables.

13.2.10 Training

Training has been a major vehicle for AVRDC in stimulating vegetable research and development work in the countries served. The Panel fully supports the high priority being assigned to training in the long-term plan, and the plans to expand the training facilities at AVRDC. The Panel also suggests that opportunities be sought for expanding and promoting more training activities in Thailand and some of the other cooperating countries.

13.2.11 Outreach

The outreach program is an important activity in AVRDC's strategy to transfer new and improved materials and technologies to the developing countries, and to strengthen the capabilities of national programs in vegetable research and development. The number of participating countries in the outreach program is expected to increase from 6 to 10 in the
next few years, and it is envisaged that a cooperative program coordinator would be required in 1985.

The Panel endorses the efforts that are being made to strengthen the outreach programs of AVRDC, and recommends that the proposed expansion be undertaken as soon as additional resources can be procured. The Panel expresses the hope that China will soon become involved in AVRDC's cooperative program.

13.3 Organization and Development

The Panel recognizes that AVRDC has over the past few years been operating under some constraints in terms of staff and financial resources. But, despite this, the Panel does not feel that a major growth in staff or resources should be recommended at this time. The Panel, however, recommends that AVRDC be encouraged to carry out some internal reorganization within its budgetary constraints, and to provide for some additional staff and facilities. The Panel supports the steps that AVRDC has taken and the modest plans that have been prepared to strengthen program staffing and develop facilities, and recommends these for the consideration of the Board. The Panel notes that the following senior staff positions will be needed in the next five years: Director of Research, Director of Development (Outreach) Plant Breeder, Economist, Farming System Specialist, Plant Pathologist, Entomologist, and Science Editor.

The Panel feels that these positions are all justified, but recommends that AVRDC Management and Board should deliberate with respect to the time table and priority for recruitment to these positions during the next 5 years, and in full recognizance of the recommendations in the programs and disciplines section of this report. The Panel notes that some of the positions will be funded from extra-core sources. With regard to the position of Director of Research, the Panel finds present arrangements for the direction of research by the Director General and the Deputy Director General quite satisfactory (see Section on Research Management). The Panel feels, however, that with the expansion programs envisaged in the next 5 years it may become necessary to recruit a Director of Research. If and when this takes place, the functional relationships of Management to the program would have to be reconsidered. The Panel notes that the timing of the recruitment of a Director of Development would also depend on the extent of the expansion of the outreach programs.
13.3.1 Physical Development

The Panel recognizes the need for some urgent physical development to support the programs for research and development. The Panel supports the requests for additional housing for senior staff, accommodation for postdoctoral research associates, a training center and additional dormitory facilities. The Panel also supports the proposed improved facilities for the Genetic Resources Unit.

13.3.2 Facilities

The Panel supports the request for improved computer facilities and associated requests for the Library and the Office of Information Services as indicated in the respective sections. The Panel notes that the various commodity programs and disciplines have listed a number of facilities as constituting constraints to their work. The Panel feels that there is need to harmonize these requests on a program or Center-wide basis in order to determine what should be provided in what order to ensure cost-effectiveness. The Panel supports the efforts of the Director General to coordinate and undertake a realistic appraisal of these requests in consultation with the staff. The Panel expresses some reservations about the requests for controlled environment rooms for work in some of the scientific disciplines. The Panel recommends that the Center should not involve itself in serious capital expenditures and high running costs for such facilities at this time.
14. OTHER STRATEGIC CONSIDERATIONS

14.1 Background

During the many discussions among the Panel members, a number of miscellaneous matters were considered, and in the following sections the Panel expresses its opinions on these matters.

14.2 Outreach Funding

The Panel has learned with some dismay that the funding for some of the projected cooperative programs will not pay all of AVRDC's costs, and in particular, do not always cover the complete cost of posting AVRDC staff to the countries concerned, although such technical assistance is required of AVRDC in the Memoranda of Understanding. The Panel does not feel that the AVRDC Board should be called upon to make core funds available for the support of cooperative programs in the Americas, for instance, at the expense of the research budget at AVRDC headquarters. While there may have been some justification for putting core funds into cooperative programs when AVRDC was trying to get such programs started to demonstrate the value of its research, in today's climate, with AVRDC's services very much in demand and with this demand increasing to the point where it could become an administrative and staffing problem, it is important that cooperative programs do not involve contributions from AVRDC's tightly stretched core budget.

This matter will become vital when, as foreseen in the near future, AVRDC will have to fill the post of Director of Cooperative Programs to share the administrative and negotiating burden now carried by the Director General's Office. An overhead allowance derived from the cooperative projects could be used to defray at least part of the costs of such a Director's salary. The Panel has no reservations about the need to fill the Director of Cooperative Programs position, but leaves the question as to when it should be filled to senior management and the Board.

The Panel recommends to the Board that the Memoranda of Understanding for all future outreach programs financed by third party donors should include not only funds to cover all expenses, but in addition, an allowance for overhead and headquarters services which is fixed at the same percentage as similar allowances agreed to by the CGIAR for outreach programs managed by other IARC's.
14.3 Seed Production Responsibilities

An important strategic consideration that directly affects the mission of AVRDC, and crosses all crops, is the problem of ensuring a reliable and adequate supply of seed of the advanced lines produced by AVRDC, which after distribution to national programs, have eventually been released by the national programs as named cultivars. Until there is a reliable supply of seed of AVRDC's improved lines available to the farmers for production in those nations releasing them, the mission of AVRDC cannot be considered to have been accomplished.

The policy of AVRDC is to provide advanced seed for testing and evaluation as the basis for licensing and release of named cultivars by the national programs. AVRDC does not name the materials it distributes, as a matter of policy. However, once a variety is released by a national program, it is that program's responsibility to maintain an adequate seed supply for its own farmers. For many of the nations evaluating AVRDC lines, the production of seed is often not feasible because the country does not have the technical infrastructure for seed production. In some cases, the climate may not be appropriate for seed production. For those countries with suitable climate for seed production, but who lack persons trained in the technology of seed production, AVRDC should be prepared to assist those nations with specialized training in seed production, together with technical consultation, as part of its training and outreach programs.

In many instances, the desirability of AVRDC's lines will be recognized by countries having no possibility of national seed production. In those cases, AVRDC should have developed an appropriate strategy for ensuring that these nations are able to obtain the seed they wish. Such strategies could include for example: 1) the identification of other national programs which are producing AVRDC derived cultivars with similar characteristics, and which would be willing to sell the seed; 2) the production of seed by AVRDC and distribution of that seed on at least a break-even basis. Clearly there are many models that might be examined to evaluate the most desirable way of ensuring that the efforts of AVRDC commodity groups are not blocked by an inability of national programs to generate the seeds they need.

The requirements for development and maintenance of seed production will vary considerably from crop to crop and nation to nation. It is essential that not only crop commodity groups but also Director General/Deputy Director General give serious consideration to the policy implications of this critical issue.
14.4 Relationships With Other International Agricultural Research Centers

Regular relationships have developed between the CGIAR Centers and AVRDC. AVRDC's Director General regularly attends the meeting of the CGIAR and its Technical Advisory Committee (TAC). He also participates in the meetings of the Centers' Directors which provide opportunities for useful exchanges. He has likewise been given the opportunity on several occasions to present AVRDC's activities to the CGIAR. On two recent occasions, the CG newsletter carried information about AVRDC, and AVRDC was recently requested to take part in the CG's impact study.

AVRDC has for some time been engaged with several IARC's in projects of mutual interest. Formal agreements signed with IRRI and IITA provide for the testing of AVRDC selections under various conditions in rice based cropping systems studied by IRRI, and under African cropping systems by IITA. AVRDC has collaborated with CIAT on a number of projects over the years, and more recently with ISNAR on a study of the national system of agricultural research in Papua New Guinea. The grants awarded to AVRDC by the IBPGR to support the multiplication and long-term storage of the Center's Chinese cabbage germplasm collection have been mentioned earlier. Discussions are currently underway with ICRISAT.

Special attention has been given to those CGIAR centers whose mandates relate to crops also included in AVRDC's program. Such is the case with IITA, which has been given worldwide responsibility for sweet potato within the CGIAR system, and which is conducting a strong soybean research program.

AVRDC, IITA, and INTSOY recently joined in discussions on a proposal for coordinating soybean research on the basis of geographical responsibilities (Africa, IITA; the America's, INTSOY; Asia, AVRDC). Considering the specific differences in the problems encountered in growing soybean on these three continents, the Panel strongly recommends that negotiations on this matter be pursued to a successful conclusion.

As regards sweet potato, the Panel notes with satisfaction the agreement for the six-month sabbatic leave of an IITA virologist at AVRDC to take place in mid-1985. This agreement is an indication of the willingness of both IITA and AVRDC to enter into working relationships which, simply from the point of view of common sense, should be encouraged.
The ultimate goal of AVRDC research is to develop technologies that are applicable and make an impact in tropical Asia.

AVRDC's initial thrust was to identify basic breeding materials that possessed adaptive mechanisms to the physical and biotic environments. They were then reconstituted into "finished" lines and then distributed to the national programs for further evaluation and selection. Initial successes have been obtained which have impact potential.

As the level of excellence in technology generation increases, however, further improvements and successes will be difficult to attain. Meanwhile, national programs are building up their competencies, and a number of them can take on expanded research responsibilities.

It would be a good strategy for AVRDC scientists to establish a close alliance through regular monitoring tours and visits with their peers in Asia. Such partnerships kindle a feeling of professional kinship rather than competition. Research competencies can also be expected to increase as a result of this strategy.

To reinforce the concept of joint participation and research relevance, AVRDC's research role may be best carried out by originating parental lines with specific characteristics and resistances and reconstituted broad-based segregating populations that can be used by national programs to produce location specific varieties. To this end, successes will provide a sense of accomplishment to both AVRDC scientists and their counterparts in national programs.
15. OVERALL ASSESSMENT

15.1 Introduction

The contents of this section represent the impressions and perspectives of the Panel as it has come to the end of its process of "sifting and winnowing" the documents, presentations, interviews, and demonstrations provided by AVRDC. Both in its sessions at the AVRDC site, and during the visits to the outreach programs, the Panel has been favorably impressed by the dedication to which the staff of AVRDC has committed themselves to the review process. The Panel members are grateful for the openness of the communications between themselves and the staff, and for the many courtesies extended to them over the past three weeks.

The process of assessing the mandate of AVRDC and of evaluating the progress of the institution can be appropriately summarized under the following headings.

15.2 Scientific Staff and Organization

The underpinnings of any organization such as the AVRDC, whose mission is predicated on the execution of high quality applied research, are dependent on the quality and productivity of its research programs. Clearly AVRDC is endowed with a staff of highly qualified, high quality senior and junior scientists together with senior managers that are both skillful and effective. The versatility of AVRDC's senior staff is matched only by the diligence and skills of the junior scientists and support personnel. Nowhere has the Panel seen such uniformly well-trained supporting scientists. Likewise, the supporting farm workforce of managers and field personnel has the dedication and skill levels that have ensured a high standard of operation.

Though it is obvious that the operational budget is severely restricted, and that physical research resources are frequently limited, it is also clear that this unusually high level of productivity has been sustained inspite of these constraints. Such output can only be attributed to dedication, ingenuity, and good management. Among the scientific staff, we have noted an esprit de corps and sense of devotion which maintains the high quality of work that exists at the Center. Apart from the benefits attributed to pleasant living conditions and generally excellent laboratory and field conditions, the fact that the institute is of a small size contributes to the sense of cohesion felt by its personnel. Senior staff and management have developed a sense
of inter-dependence that fosters a strong working camaraderie.

The Panel has noted, however, that the intimacies generated as the result of the AVRDC's small size imposes both the benefits of efficiency in management and the potential for a reluctance to be adequately critical of collegial or peer research when working to formulate or execute multi-disciplinary research projects. The Panel has sensed that throughout much of the research carried on at the Center, there is a small yet pervasive thread which indicates that, during the process of research planning and management, a much more objective and critical measure of the individual research inputs to each collaborative program should be adhered to. Such objectivity could come from greater depth and precision in defining program objectives and strategy. The Panel is also aware that the present research management structure of formulating research proposals along crop and commodity lines, in which the scientific disciplines contribute their respective inputs into planning and execution, has been working well at the AVRDC. It also recognizes the need for a close and continual monitoring of the system to ensure that an appropriate balance is maintained among the inputs of the individual disciplines to the overall program goals.

The Center enjoys the confidence of a number of national and international organizations who send personnel on secondment to become staff members at AVRDC. This makes AVRDC's core budget go considerably farther, and enables research to be conducted that otherwise could not be afforded. There is, however, a potential problem (which has not arisen, as far as the Panel is aware) that such donors may have an influence on the research program's orientation, and those seconded to AVRDC may not have the same sense of identity with AVRDC and its research objectives as AVRDC's own staff. It would seem important to the Panel that AVRDC have a voice in the selection of the staff members seconded to AVRDC.

The maintenance of a high quality research programs is dependent, in large measure, on maintaining the highest level of professional excellence among senior scientists. Important contributing factors to this need are the provision of opportunities for the scientists to interact with others in their profession through regular attendance and presentation of research results at scientific meetings, strong encouragement for scientists to publish the results of their research in refereed journals, and support for appropriate study leaves.
15.3 **Scientific Achievements**

During the past 10 years, AVRDC has made exceptional progress toward achieving many of the goals in its original mandate. Among its five mandate crops, Chinese cabbage has been successfully adapted to tropical cultivation; tomato has been significantly improved in its ability to grow and set fruit under high temperatures and high disease pressures; the architecture of the mungbean has been restructured and the genetic components for yield potential increased markedly; the soybean has been tropicalized to yield well under short day lengths in the presence of a number of biotic and abiotic stresses; and the sweet potato has been improved to produce high yields of nutritional roots for both food and animal feed.

Advanced lines of all crops are being effectively tested in national programs throughout Southeast Asia, and there is a strong and growing interest in the output of the AVRDC crops in many tropical countries in Oceania and the Western Hemisphere.

The Directors General, scientists, and staff of AVRDC have good reason to be proud of their significant accomplishments achieved in such a relatively short period of time. Such high productivity is remarkable when one considers the relatively small numbers of senior and supporting scientists engaged in the enterprise. Indeed, it is a tribute to the overall management of AVRDC that such productivity has been achieved. The Panel is well aware of the apparent constraints that low numbers of scientific and managerial personnel have imposed on the system; nevertheless it must not go unnoticed that the high level of productivity may be attributable to the fact that each scientist and manager has many tasks and many responsibilities. By having to function as generalists they have been capable of productivity that might otherwise have been unlikely, had they been afforded the luxury of being able to specialize.

15.4 **Balance Between Programs**

An important feature of the overall management of AVRDC in approaching its mandate is the relative balance in the distribution of resources that are allocated within the commodity groups. Management has provided a good balance in the distribution of personnel and funds to support research in the development of the five mandate crops.

The Panel is aware, however, that in the future the balance of support among the crops may have to be significantly shifted, in the event that particular resources are needed in
order to ensure that the advanced materials reach the farmers of tropical regions for which they have been targeted. It is possible that headquarters personnel may have to be diverted to outreach, for instance, to be replaced by a more junior scientist, but, it should be remembered, that this will add to the number of AVRDC's experienced staff.

15.5 Impact on Agriculture of the Region

As AVRDC reviews its accomplishments over the past ten years, we feel it has reason to be proud of its programs and research. Ultimately, however, its success must be measured in economic terms of how effectively it has made an impact on the agriculture and welfare of the region for which its mission has been directed. At this time, it is simply too early to make a fair assessment of AVRDC's impact on tropical vegetable production. As yet, there are only a few examples of substantial economic impact as the result of the Center's work, but these are significant where they exist. However, the wide acceptance of AVRDC as a productive research organization, and the interest evident in its advanced vegetable breeding materials, must be regarded as significant. It is, of course, important to note that the effects of the research are just beginning to reach the national agricultural systems, and that in judging the quality and productivity of the programs, the potential for very significant improvements in tropical vegetable production and supply is obvious.

Of course, the influence of AVRDC's training program has already provided important improvements in strengthening the vegetable production resources of many nations, by supplying well trained personnel. The "multiplier effect" at the national level is now becoming apparent as persons trained at AVRDC go on to receive higher advanced training or train others in their own national programs. Clearly, the training component of AVRDC is one of its great strengths.

15.6 AVRDC in the Context of International Agricultural Research

By status, scope, modalities of action, and tradition AVRDC is an international center. Although its focus is regional, the impact of its research and development activities, the dissemination of its results, and the development of its cooperative projects go beyond the geographical boundaries of tropical and subtropical Asia.

Its research, however, emphasizes the important vegetable crops and production systems of the region. An excellent reputation and image has been built under the current name
and we have found no reason to suggest or encourage a change in the name of the Center.

The Panel notes that the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) has over the years been giving consideration to the association of AVRDC with the system of IARCs in the context of possible new initiatives in international research on vegetables. It is noted that no definitive decisions or recommendations have been made in this regard, but that vegetable research remains on the priority list of TAC. The Panel notes that AVRDC has been receptive to those initiatives and has cooperated with TAC in its studies and its attempts to strengthen international vegetable research. The Panel encourages AVRDC to prepare itself flexibly for any joint efforts to strengthen vegetable research and development that may emanate from these considerations. The Panel is satisfied that AVRDC has proved its ability to organize and execute research on an international scale and has credibility. Even if there are no immediate further developments with regard to closer integration with the CGIAR system and support from the community of donors organized within it, the Panel would encourage AVRDC to continue its valuable work by ensuring a balance between its aspirations and the resources available to it. The Panel reaffirms its view that it would be in the interest of the Center, and that of international vegetable research, for AVRDC to be a full member in the international system of Centers. Even in such a case, it would be unrealistic to mandate AVRDC with worldwide competence or functions in all vegetables. It is expected that AVRDC would have a leading role in particular crops, but would collaborate with other centers in regional relays and/or worldwide network operations. It is important to note that nothing in the present AVRDC's organization or modus operandi would prevent its participation in such networks. The Panel recommends finally that the future plans of AVRDC should place greater emphasis on the humid tropics, vegetable crops of the "traditional" type consumed by the poorer people, and on production systems. By doing so it will strengthen its strategy in contributing most effectively to food and nutrition in the tropics through vegetable research and development.
### Appendix 1

**EXTERNAL REVIEW SCHEDULE**

**Monday, April 23 – Tuesday, May 15, 1984**

#### Monday, April 23

Approval of review schedule and briefing on AVRDC and its activities

<table>
<thead>
<tr>
<th>Time</th>
<th>Activities</th>
<th>Moderator</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>0800-0810</td>
<td>Greetings to the Review Committee members</td>
<td>Selleck</td>
<td>Senior staff Committee members</td>
</tr>
<tr>
<td>0810-0825</td>
<td>Discussion and approval of the review schedule</td>
<td>Vallaey</td>
<td>Senior staff and Committee members</td>
</tr>
<tr>
<td>0825-0925</td>
<td>Tour of Research Building</td>
<td>Sun</td>
<td>All Committee members, scientists</td>
</tr>
<tr>
<td>0925-0945</td>
<td>Coffee break</td>
<td></td>
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<tr>
<td>0945-1000</td>
<td>Slide show</td>
<td>Selleck</td>
<td>All Committee members</td>
</tr>
<tr>
<td>1000-1100</td>
<td>Brief history and current status of AVRDC</td>
<td>Selleck</td>
<td>All Committee members</td>
</tr>
<tr>
<td>1100-1130</td>
<td>Legume Program</td>
<td>Sundar</td>
<td>All Committee members, Selleck, Sun</td>
</tr>
<tr>
<td>1130-1200</td>
<td>Horticultural Crops Program</td>
<td>Opena</td>
<td>All Committee members, Selleck, Sun</td>
</tr>
<tr>
<td>1200-1330</td>
<td>Lunch break</td>
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<tr>
<td>1330-1400</td>
<td>Nutrition, Environment, and Management</td>
<td>Tsou</td>
<td>All Committee members, Selleck, Sun</td>
</tr>
<tr>
<td>1400-1430</td>
<td>Training and Development Program</td>
<td>Castro</td>
<td>All Committee members, Selleck, Sun</td>
</tr>
<tr>
<td>1430-1500</td>
<td>Cemplasm collection, multiplication, Tay preservation and distribution</td>
<td></td>
<td>All Committee members, Selleck, Sun</td>
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<tr>
<td>1500-1515</td>
<td>Coffee break</td>
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<tr>
<td>1515-1530</td>
<td>Office of Information Services</td>
<td>Sulzberger</td>
<td>All Committee members, Selleck, Sun</td>
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<tr>
<td>1530-1545</td>
<td>Library</td>
<td>Hwang</td>
<td>All Committee members, Selleck, Sun</td>
</tr>
<tr>
<td>1545-1600</td>
<td>Experimental Farm</td>
<td>Tu</td>
<td>All Committee members, Selleck, Sun</td>
</tr>
<tr>
<td>1600-1615</td>
<td>Office of the Comptroller</td>
<td>Chi</td>
<td>All Committee members, Selleck, Sun</td>
</tr>
<tr>
<td>1615-1645</td>
<td>Office of Administration</td>
<td>Chin</td>
<td>All Committee members, Selleck, Sun</td>
</tr>
</tbody>
</table>
Tuesday, April 24

HORTICULTURAL PROGRAM

Tomato
0800-0900 Plant Breeding (Tropical/processing) Opena/Lin
0900-0930 Plant Pathology Yuen
0930-1000 Plant Physiology Kuo
1000-1015 Coffee break
1015-1030 Entomology Talekar
1030-1045 Crop Management Sajjapongse
1045-1100 Soil Science Imal
1100-1200 Others/Discussion
1200-1300 Lunch break
1320-1320 Plant Pathology (tomato viruses) Green

Chinese Cabbage
1320-1400 Plant Breeding Opena
1400-1440 Plant Pathology Yuen/Green
1440-1510 Plant Physiology Kuo
1510-1525 Coffee break
1525-1555 Entomology Talekar
1555-1610 Crop Management Sajjapongse
1610-1625 Soil Science Imal
1625-1700 Others/Discussion

Wednesday, April 25

Sweet Potato
0800-0810 Introduction Lin
0810-0850 Breeding Lin
0850-0900 Discussion
0900-0920 Entomology (including discussion) Talekar
0930-1000 Physiology (including discussion) Kuo
1000-1010 Pathology (including discussion) Tschanz
1010-1025 Coffee break
1025-1050 Biochemistry (including discussion) Tsou
1050-1105 Crop Management (including discussion) Sajjapongse
1105-1200 Discussion on Sweet Potato Research
1200-1300 Lunch break

LEQUME PROGRAM

Mungbean
1300-1350 Breeding and International Cooperation Sundar
1350-1415 Plant Pathology Tschanz
1415-1435 Entomology Talekar
1435-1500 Plant Physiology Kuo
1500-1515 Coffee break
1515-1530 Crop Management Sajjapongse
1530-1600 Soil Science Imai
1600-1620 Chemistry Tsou
1620-1700 Discussion
2000-2200 Research Management and Organization Relations with Private Sector Selleck Sun

Tuesday, April 26

Soybean
0800-0850 Breeding Sundar
0850-0915 Plant Pathology Tschanz/Green
0915-0935 Entomology Talekar
0935-0955 Plant Physiology Kuo
0955-1010 Coffee break
1010-1025 Crop Management Sajjapongse
1025-1045 Soil Science Imai
1045-1100 Chemistry Tsou
1100-1200 Discussion
1200-1300 Lunch break

Non-Commodity Oriented Activity of NEM Program
1300-1310 Introduction Tsou
1310-1350 Nutrition Garden
1350-1410 AVRDC New Crops
1410-1440 Soil Science
1440-1500 Coffee break
1500-1520 Chemistry
1520-1600 Agricultural Economics
1600-1700 Discussion
1800-1900 Report on TAC discussion on vegetable research

Friday, April 28
0800-1130 Viewing field research plots
1130-1300 Lunch break
1300-1500 Training and Development
1500-1515 Coffee break
1515-1615 Statistical Services
1615-1700 Office of Information Services

Saturday, April 28
0800-1030 Gemplasm
1030-1045 Coffee break
1045-1145 Briefing on outreach activities
1145-1300 Lunch
1300-1500 Planning and management of AVRDC research programs
1500-1515 Coffee break
1515-1645 Discussion with the Directors General on scientific personnel, new positions, and long term plans

Report on TAC discussion on vegetable research

Chemistry
Agricultural Economics
Discussion
Report on TAC discussion on vegetable research
Discussions with D.G. and D.D.G. on mandate, charter, governance

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0800-1130 Viewing field research plots
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Gershon
Lin
Imai
Tsou
H.Y. Hung, and Prof. Chen
Ajlbola Taylor
Selleck, Sun
Selleck, Sun
Selleck/Sun
All scientists
Selleck, Sun, all scientists involved
Tsou/Yuen
All scientists involved
Selleck, Sun
Selleck, Sun, Opena
Sundar, Tsol, Tschanz
Talekar, Kuo, Lin
Gershon, Opena, Tsou
Tschanz, Talekar
Sun
Sundar
Castro
Selleck
Selleck, Sun, Opena
Sundar, Tsol, Tschanz
Talekar, Kuo, Lin
Gershon, Opena, Tsou
Tschanz, Talekar
Sun
Sundar
Castro
Selleck
Selleck, Sun
Sunday, April 29 - Thursday, May 3

1. Assessment of bilateral activities in Taiwan, Thailand and the Philippines (Group I - III)

2. Assessment of administration, management and other activities at AVDC (Group IV)

Schedule for Group I - Taiwan, Drs. Vallaey, Taylor, and Tanaka

Sunday, April 29  (Free)

Monday, April 30

0745-0900  AVDC to Hsilo by car
0900-1200  Visit (1) vegetable wholesale market; (2) specialized vegetable production areas; and (3) Hsilo Farmers Association
1200-1300  Lunch
1300-1400  Hsilo to the Taiwan Provincial Government
1400-1500  Visit the Provincial Department of Agriculture and Forestry (PDAF)
1500-1510  PDAF to the Taiwan Agricultural Research Institute (TARI)
1510-1740  Visit TARI
1740-1800  TARI to Taichung

Taichung Hotel, Taichung

Tuesday, May 1

0800-0830  Taichung to Hsinshih
0830-1030  Visit the Taiwan Seed Improvement and Propagation Station
1030-1230  Hsinshih to Taipei
1230-1400  Lunch
1400-1530  Visit the Council for Agricultural Planning and Development (CAPD)
1530-1600  CAPD to Sungshan airport
1620-1650  Taipei to Hualien via EF 311

Astar Hotel, Hualien

Wednesday, May 2

0930-1200  Visit the Hualien District Agricultural Improvement Station (DAIS)
1300-1340  Hualien to Kaohsiung via EF 924
1400-1430  Kaohsiung to Pingtung by car
1430-1600  Visit the Kaohsiung DAIS
1600-1800 Visit the Fengshan Tropical Horticultural Experiment Station (THES)

Holiday Inn, Kaohsiung

Thursday, May 3
0800-0840 Kaohsiung to Tainan
0840-1040 Visit the Tainan DAIS
1040-1100 Tainan to Yungkang
1100-1300 Visit the President Enterprises, Inc.
1300-1400 Yungkang to Chiayi
1400-1630 Visit the Chiayi Agricultural Experiment Station
1630-1730 Chiayi to AVRDC

Schedule for Group II - Thailand. Drs. Dion, Lantican and Ou

Sunday, April 29
0830-0930 AMF C to Kaohsiung International Airport
1100-1220 Kaohsiung to Hong-Kong via CI 831
1500-1640 Hong-Kong to Bangkok via CI 819

Rama Gardens Hotel

Monday, April 30
AM 1. Visit Kasetsart University and meet with Vice Rector Dr. Chongrak Princhananda.
2. Visit the Department of Agriculture and meet with Director General Dr. Yookti Sarikaphuti.
3. Visit the Department of Agricultural Extension and meet with Director General Dr. Pisit Sasiphalin and staff.
PM 1. Briefing of AVRDC Thailand Outreach Program (TOP/AVRDC) by Dr. Charles Y. Yang.
Evening Welcome banquet

Tuesday, May 1
AM Bangkok to Kamphaengsaen Campus of Kasetsart University
1. Meet with the Vice Rector of Kasetsart University
2. Visit research facilities of KPS and field plots of TOP
PM 1. Visit TOP training facilities
2. Fly to Chiang Mai
Wednesday, May 2

AM Visit Chiang Mai University, Maejo AIT
PM Fly back to Bangkok

Rama Gardens Hotel

Thursday, May 3

AM Discussion with Dr. Charles Y. Yang
1415-1755 Bangkok to Hong-Kong via CI 804
1930-2045 Hong-Kong to Kaohsiung via CI 832
2130-2230 Kaohsiung to AVDC

Schedule for Group III - Philippines. Drs. Dumsday and Williams

Sunday, April 29

0830-0930 AVRDC to Kaohsiung International Airport
1100-1220 Kaohsiung to Hong-Kong via CI 831
1630-1820 Hong-Kong to Manila via CX 903

Manila Gardens Hotel

Monday, April 30

0900-1200 Conference, Deputy Minister for Agriculture Domingo Panganiban, and BPI staff at MA, Quezon City
1200-1300 Lunch
1300-1430 Trip to Los Banos
1430-1700 Conference with the National Crop Testing Project Leaders/scientists coordinated by Director Dely Gapasin of PCARRD:
   a. Dr. F. Quebral - Field Legumes
   b. Dr. Rasco - Crucifers
   c. Dr. S. Carpena - Sweet Potato
   d. Dr. Valdez - IRB pathologist
   e. Dr. R. Villareal - Vegetables
1900 Dinner sponsored by PCARRD

City of Springs Hotel, Los Banos

Tuesday, May 1

0800-1200 Conference with POP and BPI staff and evaluation of AVRDC/POP Program at Economic Garden, Los Banos
1200-1330 Noon break
1330 Continuation of POP evaluation
1900 Dinner sponsored by BPI/POP

Wednesday, May 2

0800-1000 Meeting with Dr. R. Villareal, IPB Deputy Director
1000-1200 Visit to IRRI
1200-1330 Noon break
1330-1530 IRRI, Multiple Cropping Division - Conference with Dr. V. Carangal and staff, field visit
1500-1800 Conference with executive Director R. Valmayor and Director D. Gapasin and Staff, CID, PCARRD

Thursday, May 3

0700-0830 Trip to Technology Research Center, Manila, coordinated by Dr. R. Villareal
0830-1400 Confer with Mrs. Sylvia Munoz Ordonez and staff - TRC.
1400-1430 Trip to Manila International Airport
1600-1745 Manila to Hong-Kong via PR 310
1930-2045 Hong-Kong to Kaohsiung via CI 832
2130-2230 Haohsiung to AVDC

Friday, May 4

0800-1000 Debriefing of outreach (closed session)
1000-1015 Coffee break
1015-1200 Consultation with Junior Staff
1015-1200 Administration
1130-1200 Library
1200-1300 Lunch break
1300-1500 Discussion with the Directors General on Outreach Reviews
Junior Staff consultation
1500-1515 Coffee break

Saturday, May 5

0830-1100 Administrative and financial management
1000-1015 Coffee break
1100-1200  Administrative management  Vallaeys  Chin  Dion

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Saturday, May 5 - Monday, May 7  Preparation of first draft of reports
Tuesday, May 8 - Friday, May 11  Assembling and editing draft report in association with AVRDC management and staff

Saturday, May 12

0800-1200  Report to AVRDC's management staff with some Board members attending
1400-1700  Closed session of the Panel to consider observations of management and staff prior to finalizing Review report.

Monday, May 14

Presentation of review report to 17th meeting of the AVRDC Board of Directors.
Appendix 2

TERMS OF REFERENCE

INTRODUCTION

The experience gained by the CGIAR and its Technical Advisory Committee (TAC) in the conduct of quinquennial reviews of international agricultural research institutes, centers and programs has been utilized for the AVRDC external review. The scope, purposes, and procedures suggested below follow the general outline developed and utilized in TAC reviews.

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 Center, 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; and

(b) Present and possible future areas of work.

(ii) The relevance, scope and objectives of the present program of work and budget of the Center, and of its forward plans for the next five years in relation to:

(a) Its mandate and the criteria for the allocation of resources;

(b) The ongoing activities of other international institutes and organizations, and of the 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 Center in carrying out its mandate, and the mechanisms for their formulation; and

(d) The Center'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 Center 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 programs, their methodologies, their specialization and decentralization, and the participation of the research staff therein;

(d) The adequacy of the research support and other facilities; and

(e) The management of the scientific and financial resources of the Center and the coordination of its activities.

(iv) The impact and usefulness of the Center'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 programs; and

(d) Cooperation with other international institutes and organizations.

(v) Constraints on the Center'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 cooperating institutions, the Center's Director General or its Board of Directors, may request.

On the basis of its review, the Mission will report to the Board Chairman and the Advisory Committees of AVRDC its views on the need for any changes in the basic objectives or orientation of the Center's programme elements, and on means of improving the efficiency of operations, and will make proposals for overcoming any constraints identified under item (v).
## Appendix 3

### Membership of the Review Panel

<table>
<thead>
<tr>
<th>Name</th>
<th>Position/Institution/Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Guy Vallaey</td>
<td>Scientific Advisor, GERDAT-IRAT Chairman, Committee for International Agricultural Research, Ministry of Research c/o IRAT 45 bis, Avenue de la Belle Gabrielle 94130 Nogent sur Marne France</td>
</tr>
<tr>
<td>Dr. George Dion</td>
<td>Secretary 195 A, Promenade du Portage Hull, Quebec J8X 2K6 Canada</td>
</tr>
<tr>
<td>Dr. Robert Dumsday</td>
<td>Senior Lecturer/Agricultural Economics School of Agriculture La Trobe University Bundoora, Victoria, 3083 Australia</td>
</tr>
<tr>
<td>Dr. Ricardo Lantican</td>
<td>Director Institute of Plant Breeding University of the Philippines at Los Banos College, Laguna Philippines</td>
</tr>
<tr>
<td>Dr. S. H. Ou</td>
<td>Special Chair Professor National Science Council Taiwan Forestry Research Institute 53 Nanhay Road, Taipei 107 Taiwan, Republic of China</td>
</tr>
<tr>
<td>Dr. Akira Tanaka</td>
<td>Professor of Plant Nutrition Faculty of Agriculture Hokkaido University North 9 - West 9, Kita Ku Sapporo 060 Japan</td>
</tr>
<tr>
<td>Dr. T. Ajibola Taylor</td>
<td>Senior Research Officer ISNAR Oranje Buitensingel 6 2511 VE, The Hague Netherlands</td>
</tr>
<tr>
<td>Dr. Paul H. Williams</td>
<td>Professor of Plant Pathology 1630 Linden Drive University of Wisconsin Madison, Wisconsin 53706 USA</td>
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Appendix 4

PROVISIONAL LIST OF MAIN ISSUES

1. The role of AVRDC as a vegetable center in relation to national and international institutions.

2. Management and reporting systems of research projects.


4. Post harvest technology - its focus and relative importance in future AVRDC programs.

5. Geographical distribution of off-campus activities as related to future demands in the tropics.

6. Basic research requirements of AVRDC. Respective roles of headquarters research, collaborative research and contract research (not utilized to date).

7. Scope and future activities of AVRDC
   (a) Range of mandate crops, priorities in relation to present importance and future potential.
   (b) The role and focus of farming systems research and integrated projects with other international centers.
Appendix 5

Organizations That Have Signed Memoranda of Understanding
With the Asian Vegetable Research and Development Center

Universities

University of Georgia (USA) (1980)
University of Illinois, INTSOY (USA) (1975, 1983)
Kasetsart University (Thailand) (1981)
University of Maryland (USA) (1982)
Michigan State University (USA) (1982)
Mindanao State University (The Philippines) (1978)
University of Missouri at Columbia (USA) (1978 and 1984)
North Carolina State University (USA) (1981)
University of Rhode Island (USA) (1981)
Virginia Polytechnic Institute (USA) (1981)

International Agricultural Research Centers

IITA International Institute of Tropical Agriculture (Nigeria) (1981)
International Rice Research Institute (The Philippines) (1981)

International Organizations

International Development Research Centre (Singapore) (1983)

Regional Organizations

Caribbean Agricultural Research and Development Institute (CARDI) (Trinidad) (1980)
Centro Agronomico Tropical de Investigacion y Ensenanza (Costa Rica) (1979)
Inter-American Institute for Cooperation on Agriculture (Costa Rica) (1982)
Southeast Asian Research Center for Graduate Study and Research in Agriculture (Philippines) (1976)

National Organizations (Outside of Taiwan)

Agency for Agricultural Research and Development (Indonesia) (1983)
Bangladesh Agricultural Research Council (Bangladesh) (1976)
Deutsche Gesellschaft für Technische Zusammenarbeit, CTZ (FR Germany) (1980)
Economic Planning Unit, Prime Minister's Dept. (Malaysia) (1984)
Institute for Agricultural Research of Panama, IDIAP (Panama) (1983)
Ministry of Agriculture (Kingdom of Jordan) (1975)
Ministry of Agriculture and Water (Saudi Arabia) (1978)
Office of Nutrition, USAID (USA) (1979)
Philippine Council for Agriculture and Resource Research, PCARRD (Philippines) (1975)
Plant Disease Research Lab., SEA, USDA (USA) (1978)

Organizations in Host Country

Food and Fertilizer Technology Center for the Asian and Pacific Region (1983)
IBM Taiwan Corporation (1978)
Appendix 6

Collaborating Organizations

Argentina
Crawford, Klien & Cia
Instituto Nacional de
Technologia Agropecuaria
Semillero Elceibo

Australia
Berrimah Research Farm
Commonwealth Scientific and
Industrial Research Organization
Department of Primary
Production
Institute of Biological
Resources
University of Queensland

Bahrain
Agricultural Directorate

Bangladesh
Bangladesh Agricultural
Research Council*
Christian Reform World Relief
Committee
Institute of Nuclear
Agriculture
Mennonite Central Committee

Bolivia
Cole
de Obras Publicas
ENC Oleaginosas
ROC Technical Mission

Brazil
EMBRAPA
CU/NCSU Project
Instituto Adventista
Agro-industrial Manuas
Instituto Nacional de Pesquisas
da Amazonas
Universidad Federal de Vicosa

Brunei
Department of Agriculture

Burma
IRRTI-Burma Project

Canada
Ministry of Agriculture and
Food
King Grain Co., Ltd.

Colombia
International Center for
Tropical Agriculture

Costa Rica
Centro Agronomico Tropical de
Investigacion y Ensenaza
Universidad de Costa Rica
Inter-American Institute for
Cooperation on Agriculture

Egypt
Institute of Agricultural
Research
Ministry of Agriculture and
Fisheries

Fiji
Sigatoka Research Station

Gambia
Department of Agriculture

Ghana
USAID Mission

Germany
Biologische Bundesanstalt
Deutsche Gesellschaft fur
Technische Zusammenarbeit
(GTZ)

Guatemala
Plenty Agricultural Project
Instituto de Ciencia y
Tecnologia Agricolas

Guyana
Guyana Sugar Corporation

Haiti
Compagnes de Jesus
Organisme de Development du
Nord
Honduras
CEDEN
Escuela Agricola Panamericana
ROC Technical Mission
UNHA

India
Department of Agriculture,
Tamil Nadu
G. B. Pant University of
Agriculture and Technology
Indian Agricultural Research
Institute
Indian Council of Agricultural
Research
Maharashtra Association for the
Cultivation of Science
Research Institute
National Bureau of Plant
Genetic Resources
Punjab Agricultural University
Regional Pulses Research
Center, Tamil Nadu
Tamil Nadu Agricultural
University

Indonesia
AARD
Balittan Sukarami
Balittan Sukamandi
Central Research Institute for
Food Crops
Institute Pertanian Bogor
National Agricultural Extension
Project
P. T. Patra Tani Palembang
ROC Agriculture Technical
Mission
Sekolah Altikab den Kejuran -
Irian Jaya

Italy
International Board for Plant
Genetic Resources (IBPGR)*
United Nations Food and
Agriculture Organization

Japan
Japanese International
Cooperation Agency (JICA)
Nagasaki Agriculture and
Forestry Station - Isahaya

Nihon Agricultural Production
Institute-Chiba
Kyushu University
Nagasaki Agriculture and
Forestry Station
Ministry of Agriculture,
Forestry and Fisheries
University of Osaka
Vegetable and Ornamental
Crops Research Station
Tropical Agricultural Research
Center

Jordan
Ministry of Agriculture*

Korea
Crop Experimental Station,
Office of Rural Development
Horticultural Experimental
Station, Office of Rural
Development
Korean Atomic Energy Commis-
sion

Liberia
Central Agricultural Research
Institute

Malaysia
Agricultural Research Center,
Senmongok
Department of Agriculture,
Sarawak
Joint Malaysian Soybean
Breeding Project
Methodist Church Agricultural
Rural Development Program
- Sarawak
Malaysian Agricultural
Research and Development
Institute (MARDI)
Rubber Research Institute
Rural Development Corpora-
tion, Sabah
University Kebangsaan -
Malaysia
University of Malaysia
University of Pertanian -
Malaysia
Mauritius
Ministry of Agriculture and Natural Resources
University of Mauritius

Netherlands
International Service for National Agricultural Research (ISNAR)
Glasshouse Crops Research and Experimental Station
Wageningen University of Agriculture*

Nigeria
International Institute of Tropical Agriculture (IITA)*
National Horticultural Research Institute

Panama
Instituto de Investigacion Agropecuaria de Panama
Ministry of Agriculture*

Pakistan
Agricultural Research Institute
Nuclear Institute for Agriculture and Biology
Technical Services Association Agricultural Project

Paraguay
Servicio Agropecuario Chaco Central

Papua New Guinea
Department of Primary Industries

Peru
Amazon Jungle Research Project
Instituto Nacional de Investigacion Agraria
Universidad Nacional Agraria

Philippines
Asian Development Bank
Bureau of Plant Industry
Central Philippines University

International Rice Research Institute (IRRI)*
Mindanao State University*
National Food and Agriculture Council*
Philippines Atomic Energy Commission
Philippine Packing Corporation
Philippines Council for Agricultural and Crop Resources Research (PCARR)*
Philippines Root Crop Research and Training Center
Society for the Advancement of the Vegetable Industry
South East Asian Center for Graduate Study (SEARCA)
Institute of Tropical Agricultural Research
University of the Philippines, Los Banos

Reunion
Institut de Recherches Agronomiques Tropicale

Saudi Arabia
Ministry of Agriculture and Water
ROC Agriculture Technical Mission

Senegal
Center for the Development of Horticulture

Sri Lanka
Agricultural Development Authority
Department of Agriculture
University of Peradeniya - Department of Agriculture and Horticulture

Sweden
International Foundation for Science

Tanzania
Yole Agricultural Center

Tahiti
GERDAT-IRAT
Thailand
Asian Institute of Technology
Chiang Mai University
Kasetsart University*
Khon Kaen University
Ministry of Agriculture
National Science Council

Taiwan ROC
Academia Sinica
Agricultural Association of China
Agricultural Engineering Research Institute
Asian and Pacific Food and Fertilizer Technology Center*
Chiayi Agricultural Experimental Station
Chinese Culture University
Chu-Pei Farmers' Association
Council for Agricultural Planning and Development
Dah-cheng Farmers' Association
Ehr-lin Farmers' Association
Ehr-ren Farmers' Association
Fengshan Tropical Horticultural Experimental Station
Food Industry Research and Development Institute
Fu-Jin University
Hsih-fu Cooperative Farm
Hsinchu District Agriculture Improvement Station
Hsin-kang Cooperative Farm
Hsin-kang Farmers' Association
Hwalien District Agriculture Improvement Station
IBM Taiwan Corporation*
I.-tsu Cooperative Farm
Kaohsiung District Agriculture Improvement Station
Lu-chu Cooperative Farm
Lun-yang Cooperative Farm
Lu-tsau Cooperative Farm
Mountain Agricultural Resources Development Center
Nan-ho Cooperative Farm
National Cheng-kung University
National Chung-hsiung University
National Science Council
National Taiwan University

Provincial Department of Education
Ren-bay Farmers' Association
Shanhua Farmers' Association
Shin-tzou Farmers' Association
Shui-lin Farmers' Association
Taichung District Agriculture Improvement Station
Tainan District Agriculture Improvement Station
Tai-pau Farmers' Association
Taipei District Agriculture Improvement Station
Taitung District Agriculture Improvement Station
Taiwan Agricultural Research Institute
Taiwan Seed Improvement and Propagation Service
Taiwan Sugar Research Institute
Tung-Shih Farmers' Association
World Vision

Trinidad
Caribbean Agricultural Research and Development Institute

United Kingdom
National Vegetable Research Station, Wellesbourne
University of Reading

United States
Alabama A&M University
Cornell University
East-West Center
International Soybean Program
International Agricultural Development Service
International Mineral Corporation
International Volunteer Service
Iowa State University
IRI Research Institute
Kresge Foundation
Land O'Lakes, Inc.
Louisiana State University
Mayaguez Institute of Tropical Agriculture
Michigan State University*
North Carolina State University*
Oklahoma State University  
Organic Farm Research Center  
Rockefeller Foundation  
Rodale Research Center  
Sacramento Valley Milling Co.  
Texas A & M University  
University of Arizona  
University of Arkansas  
University of California  
(Berkeley)  
University of California  
(Davis)  
University of Georgia*  
University of Hawaii  
University of Illinois*  
University of Maryland*  
University of Missouri*  
University of New Hampshire  
University of Puerto Rico  
University of Rhode Island  
University of Wisconsin  

US Department of  
Agriculture*  
US Agency for International  
Development*  
US Vegetable Laboratory  
Virginia Polytechnic Institute  
Volunteers in Asia  
Water Isle Botanical Garden  

Venezuela  
Fondo Nacional de  
Investigaciones  
Agropecuarias  

Zaire  
MAST/USAID Project  

Zimbabwe  
Seed Maize Co-op Company  

* Formal Agreement Signed