

EXECUTIVE SUMMARY

- A. Problem and Overview: Nitrogen is an essential element required in large quantities for maximum plant growth and must be constantly replenished in soils used for agricultural production. Nitrogen fertilizer is an expensive input for LDC farmers because of the high energy inputs (as petroleum or natural gas) that are necessary for its chemical synthesis. Biological nitrogen fixation (BNF) which involves the fixation of atmospheric nitrogen by soil bacteria (Rhizobium) in root nodules of leguminous crops is an alternative method for providing part of this nitrogen to the crops in an economical manner.
- B. U.S. Assistance: The majority of the financial resources of the NIFTAL project have been provided by USAID under Project No.: 931-0613, Contract No.: DAN-0613-C-00-2064-00 with the University of Hawaii.
Project costs to date: 1975 - 1986 \$8,662,591

The original goal of NIFTAL was to increase food production in developing countries through greater exploitation of nitrogen fixation by tropical legumes. Specific objectives included the development and maintenance of a Rhizobium germplasm resource, the development and operation of a multilevel training program for LDC legume workers and scientists in all aspects of legume technology, dissemination of information to scientists, the development and evaluation of technology to improve legume production, and the initiation of field trials on BNF technology through a network of cooperators in developing countries (INLIT).

C. Purpose of Evaluation

This review in the project's tenth year of existence, was designed to provide an evaluation of the progress which has been made during the last four years and to make a recommendation on whether the project should be continued in the future.

D. Findings

1. NIFTAL's multi-dimensional program has made significant progress in attaining its goal and the program is of overall high quality.
2. The overall administration and administrative structure of NIFTAL has been effective and promises to continue so in the future. The previous project Director provided needed visibility to the program and the new Director should be able to maintain the direction and shows promise in providing even greater strength within the program. The integration of NIFTAL with the University of Hawaii has improved and recent commitments of resources should strengthen the program.
3. The enthusiasm, professional competence, and morale of the scientific staff was impressive.
4. The physical facilities, equipment, and infra structure for NIFTAL are adequate.
5. The NIFTAL training and communication strategy for BNF technology has proven to be unique and effective.
6. The documentation of the impacts and benefits derived from NIFTAL's outreach programs should be improved and given greater emphasis.
7. The INLIT program is in many ways the focal point for all of NIFTAL's other efforts yet is the area of the total program most in need of improvement.

8. The NIFTAL Resource Center in Bangkok has a great potential to provide professional and technical training appropriate to local and regional needs of Southeastern Asia. The initiative should be followed closely and expanded into other areas as appropriate.

E. Project Design and Policy Implication

N/A

F. Recommendations - Selected

1. Overall Evaluation - (a) The project should be continued with increased funding above current levels if at all possible.
2. Project Administration - (a) An Advisory Board to NIFTAL should be established. Membership should include University of Hawaii administration and BNF experts from both developed and developing countries. (b) The new contract agreement should be modified to make possible (indeed encourage) mission buy-ins for important services which NIFTAL is uniquely qualified to provide.
3. Research - (a) Research should be continued as an integral part of the NIFTAL project at a similar proportion of the budget. The sub-contract with the University of California-Davis should be discontinued and the funds used to support research at the Maui site. (b) The Rhizobium germplasm collection should be reduced in size and those retained more completely characterized. (c) Research on soil and environmental stress factors and cropping systems should be critically examined to provide a focus on areas not covered by research groups at other U.S. and foreign research centers. (d) Graduate student research participation in NIFTAL, Maui location, should be enhanced.
4. Travel and Communication - (a) Strategies, programs, and financial support need to be continually developed for highly focused and specific short courses in LDC countries. The demand is likely to increase. (b) More attention needs to be focused on the nurturing and support of programs of LDC scientists and technicians who have been interns, workshop participants, or INLIT cooperators. (c) NIFTAL must improve the documentation of the impacts and benefits of all of their outreach programs.
5. Outreach Programs - (a) The INLIT program must be strengthened and improved to include more follow-up of INLIT A experiments and to implement greater participation of INLIT cooperators in INLIT B trials. (b) Consultative services are important but this activity must be evaluated to assure adequate availability of financial support to prevent disruption of other program activities. (c) The NIFTAL Resource Center concept should be evaluated and expanded into other regions as appropriate.

Project Title: Nitrogen Fixation in Tropical Agricultural Legumes.

Project No.: 931-0613

Contract No: DAN-0613-C-00-2064-00

Summary of Findings and Recommendations of the Review Team

Overall Evaluation:

It is the consensus of the Review Team that the NifTAL program has done an effective job of addressing its original goal to increase food production in developing countries through greater exploitation of nitrogen fixation by tropical legumes. The multi-dimensional program has made important progress to reach its goal and the program is overall of high quality.

The team strongly recommends that the project be continued with an increased funding above current levels if at all possible.

I. Project Administration

- A. The overall administration and administrative structure of NifTAL has been effective and promises to continue under the new Director.
- B. An Advisory Board to NifTAL should be established which would include University of Hawaii administration and BNF experts from both the developed and developing countries.
- C. The integration of NifTAL with the University of Hawaii has improved, but efforts for further improvement must continue. The most recent commitment by the College of Tropical Agriculture of a tenure track position and

possible assignment of two or three additional positions is an important step in the process of program integration.

- D. The overall quality and morale of the senior and support staff are high. The new Director should reexamine the allocation of responsibilities of the staff with a view to utilizing them where their talents and current interests would be most effective.
- E. AID should provide assurance of the project's funding status at the earliest possible time to assure the retention of key staff members.
- F. The new contract agreement should be modified to make possible (indeed encourage) mission buy-ins for important services which NIFTAL is uniquely qualified to provide.

II. Research

- A. The Review Team was impressed by the enthusiasm and scientific competence of the research staff. This group of individuals have carried out productive research in a number of areas and are commended for publishing the results in respected, refereed journals.

The following research areas are particularly noteworthy:

1. Research on improved inoculant production technology appropriately scaled for different LDC needs and technical capability.
2. The selection and characterization of a limited number of Rhizobium strains for economically important tropical legumes.
3. The development of an anti-sera bank for the strains of Rhizobium recommend for economically important legumes.

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- B. The facilities, equipment, and field sites appear to be adequate.
- C. Research should be continued as an integral part of the NifTAL project at a similar proportion of the budget. The sub-contract with the University of California - Davis should be discontinued and the funds used to support research at the Maui site.
- D. The size and content of the Rhizobium germplasm collection should be thoroughly examined. A smaller collection of more completely characterized strains would be of more use than the large accumulation of uncharacterized strains.
- E. Research on soil and environmental stress factors and cropping systems should be critically examined to provide a focus on areas not covered by research groups at other U.S. and foreign research centers. The development of techniques for assaying dinitrogen fixation by leguminous trees is one area which seems to fit this criterion.
- F. NifTAL's administration should study ways which will enhance graduate student research at Maui. Likewise, efforts should be made to encourage and support scientists from both developed and developing countries. These assignments should be well planned to fit into NifTAL's objectives and be for a minimum of six months.

III. Training and Communication

- A. The Review Team commends the NifTAL staff for the development of a training and communication strategy for BNF which is unique and effective.

- B. The need for highly focused and specific short courses in LDC countries remains high. Strategies to fulfill these needs within financial and staffing constraints must be developed.
- C. The Team supports NIFTAL's plan to develop a modular approach for training materials.
- D. The value of the intern program for training of LDC technical and scientific staff is unchallenged. However, a strategy must be developed to more effectively integrate intern training into normal operations and to reduce the disruptive potential of the program.
- E. NIFTAL should do everything possible to enhance its visibility in USAID Washington, D.C., USAID Missions, and with LDC decisionmakers.
- F. Insufficient attention has been focused on nurturing and supporting the programs of LDC scientists and BNF technicians who have been interns, workshop participants, or INLIT cooperators.
- G. An effort should be made to improve the documentation of the impacts and benefits derived from all of NIFTAL's outreach programs. This would include the INLIT network, workshop training and intern training.

IV. Outreach Programs

- A. The INLIT program is in many ways the focal point for all of NIFTAL's other efforts. Yet, it is the area most in need of improvement. Specifically the Review Team recommends:
 - 1. Greater follow-up on reasons for negative responses (or no responses) from cooperators in INLIT A experiments.
 - 2. Develop plans and implement INLIT B trials with as many LDC Scientists and geographical locations as possible. The serum bank is much too valuable a resource to be left unused or underused and an increased initiative in the INLIT B studies will utilize this resource.

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- B. Consultative services by NIFTAL staff is crucial and important for sustaining BNF research and technology transfer in LDCs. The Review Team recommends that this activity should be encouraged but selectively employed.
- C. The Review Team was impressed by the potential of the NIFTAL Resource Center in Bangkok to provide professional and technical training appropriate to local and regional needs. This initiative should be followed closely and expanded into other areas as appropriate.

Overview

The NifTAL (Nitrogen Fixation by Tropical Agricultural Legumes) project was initiated in FY 1975 with funding from USAID S&T/AGR. This review, in the project's tenth year of existence, was designed to provide an evaluation of the progress which has been made during the last four years and to make a recommendation on whether the project should be continued in the future. If the recommendation for continuation is made, the Review Team was requested to offer suggestions which would further improve NifTAL's ability to carry out its stated objectives. This Review was the third of this type, the last review being conducted in July of 1980.

The goal of the original project was to increase food production in developing countries through greater exploitation of nitrogen fixation by tropical legumes. Specific objectives included the development and maintenance of a Rhizobium germplasm resource, the development and operation of a multilevel training program for LDC legume workers and scientists in all aspects of legume technology, dissemination of information to scientists, the development and evaluation of technology to improve legume production, and the initiation of field trials on BNF technology through a network of cooperators in developing countries. The original goal and these basic objectives have not changed during the history of NifTAL. However, NifTAL has proven to be a dynamic program -- developing new thrusts and approaches to reach its stated goals. Recent examples include providing assistance through consultant contracts and the BNF Resource Center in Bangkok, Thailand.

Project Administration

The Review Team evaluated the operation of the project from the point of view of its organization, its relationship with the host institution (University of Hawaii), the facilities and equipment available, staffing of the project, financial aspects, and management practices.

Organization

The Project is administered by a Director, the Director currently being Dr. Ben Bohlool. Dr. Bohlool has only recently been appointed, replacing Dr. Jake Halliday. There are four administrative sections: Research; Outreach; Communications/Training; and Administration, each led by a section head.

There are certainly several other options for organizing the project's activities. However, it is the opinion of the Review Team that the one chosen is suitable to the project needs and has proven highly successful. The current organization succeeds quite well in functioning without internal jurisdictional impediments; and communication across section boundaries is very effective. The NIFTAL project has, through its existence, shown itself to be dynamic -- and thus may require significant adaptation in the future as its tasks and involvement continue to change. The combination of communications and training under one section seems quite workable with the present project needs and staffing. However, when communication requirements accelerate, largely because of the needs of the regional resource centers, this activity might benefit by being separated from training.

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In any organization dealing with activities at this level of complexity, it is important to provide a mechanism for advice and guidance. Advisory mechanisms generally afford a perspective in which the staff can more realistically pursue project goals and activities as well as a means for liaison with other elements of the community. The project currently does not have an effective advisory apparatus. Consideration should be given to the identification and establishment of an advisory group.

Host Institution

The Project is administered by the University of Hawaii within its College of Tropical Agriculture and Human Resources as a part of the Department of Agronomy and Soil Science.

The Project does not seem as well integrated into the activities of the College as would be desirable. Both the Dean and the Director of the Institute of Tropical Agriculture and Human Resources expressed to the Review Team their strong support for the project and stated that it was included as an important element in their long-range plans for tropical agriculture. Nevertheless, its remoteness from the main campus necessarily creates a need for special efforts to bring the project more closely in touch with the college and with the intellectual and professional resources of the university.

While it appears that progress has been made since the last review in the matter of relations between the Project and the main administration, much remains to be done. The commitment of the college administration to provide at least one tenure track position to NIFTAL is a major decision that will

enhance the integration of the program with the university, college, and the Department of Agronomy and Soil Science.

Facilities and Equipment

The Project is housed in an abandoned high school on the island of Maui in a building leased from the county at a nominal fee. From everything observed, it appears that NIFTAL currently has adequate space. In the future, additional parts of the school that currently stand in disrepair could be renovated and utilized. Attempts are being made to identify other sources of funds to renovate the high school's administration building.

There is a variety of laboratory and other equipment used in the Project but none of it is unduly sophisticated. The Review Team found this equipment to be appropriate to accomplishing the Project goals, and suitable both for the research program and for training individuals from developing countries. The equipment on which LDC trainees gain experience can be obtained, installed, operated, and maintained in the expected LDC environment.

There is currently a need for effective routine interactive communications with the regional resource center in Bangkok and with other future regional resource centers. The elements of a computer conferencing system are in place but the system is not yet operational, pending approval of its operation by the Government of Thailand. As the Project spawns more regional centers and as the centers become more active, the needs for interactive communications will increase. In addition, there will be an increasing need to provide better access to data bases and other sources of information around the world.

Staffing

The staff consists of a Director (also known as the P.I.); four section heads (one of whom also serves as Associate Director of the Project); a number of researchers, research associates, and support people, many of whom are only part-time on the Project; and an Executive Director and one staff person at the Regional Resource Center in Bangkok.

Because of the broad objectives and multiple activities of the Project, but also because of funding stringencies, most staff members have responsibility for several distinct and minimally related responsibilities. This diversity has the potential to cause the staff to feel "schizophrenic." Nevertheless, the staff gives evidence of functioning quite well despite (perhaps in some degree because) of their disparate responsibilities.

Staff turnover can be a problem if it destroys the continuity of project efforts; it can be an indication of an underlying problem affecting staff morale; or it can merely be a result of normal professional maturation and career development of individuals. Staff turnover in the Project has been substantial in the past, but in the opinion of the Review Team it has not been detrimental to progress on program objectives. In the Review Team's judgment, staff turnover on the Project could be reduced somewhat if the staff were less isolated from the university life of the main campus and made to feel more connected to the professional community.

Staff morale of any project can be improved, but seems to be satisfactory at this time. Morale during this year would benefit from an early assurance

of Project continuation. This assurance would also increase the likelihood that staffing would remain stable since the need to search for other professional positions would be eliminated.

Certain of the staff have been doing essentially the same jobs for an extended time period. While this clearly has value in terms of the continuity of the effort, it can be stultifying to the individual and deprive the program of the creative enthusiasm that a newly assigned individual could bring to focus on these tasks. Periodic reexamination of responsibilities should be made by the Director and new assignments made to maximize available talent and interest.

Financial

This Project has been in existence for almost ten years with the largest amount of funding coming from AID S&T/AGR. Under the terms of the current agreement, AID mission "buy-ins" are not permitted; and if missions desire NIFTAL services, they must arrange for them outside the agreement. This is a burdensome process and shunned by missions that otherwise might have an interest in "buying-in." The result is a reduction in potential funds available for enhanced program expansion or development.

In 1983, spending at a higher rate than normal was authorized by AID in response to the availability of funds from a different program. This action was later retracted when it was found that the addition of those funds was technically outside of AID's authority under the agreement. This action, although unintended, has proved disruptive to the Project spending pattern and could require termination of the program effort about three months

earlier than initially anticipated. Changes in the wording of the current agreement should be made to insure that problems of a similar nature do not occur in the future.

Management

Operation of the Project appears to be informal but effective. There is evidence that management does pay attention to planning in both the short- and long-term. Staff interaction seems effective and without substantial impediment. The administrative support activities are well tuned to the needs of the project and are well handled. Management of operations is crucial to the success of a Project such as this and it has been a highly positive aspect of the effort to date.

In the future, there will be stresses on the Project administration arising from the need to provide better communication with regional resource centers, to support a reconfigured INLIT activity and to advance to the later stages of the NifTAL Project. Networking with researchers in developing and developed countries will be important and more effective access to data and other information on BNF from centers around the world will become necessary.

Research

The NifTAL staff have maintained an active research program on Maui in a variety of research areas. Research areas include the development of improved appropriate technology for the production and delivery of legume inoculant; the collection, selection and evaluation of Rhizobium germplasm for important tropical legumes; the development of cropping systems which optimize the benefits of BNF, and limited research on the influence of some

abiotic stresses on the effectiveness of the legume symbiosis. There have been three sub-contracts for projects dealing with biostatistics (Cornell University), the economics of BNF (University of Minnesota), and the influence of soil stresses on the symbiotic performances of legumes (University of California, Davis).

Evaluation

The lab facilities at Maui are adequate, though Spartan, and there are field research areas available with soils representative of several climatic zones. The current support staff and research associates are competent and take pride in their work, and the Review Team was impressed by the enthusiasm of all the NifTAL researchers. Research has been very productive; NifTAL scientists have made their work known at important scientific conferences, and the results have been published in widely-read and respected refereed journals.

NifTAL researchers have made positive contributions to our knowledge of symbiotic N fixation, and these contributions have increased NifTAL's prestige and credibility. Opportunity for research is a major factor in attracting skilled scientists to Maui, and both Outreach and training functions benefit from having an in-house research back-up.

Research has progressed well on simplifying technology for rhizobia inoculant production in LDCs. This project has been unique; and the excellent results obtained thus far can be rapidly disseminated by means of training courses and visiting "interns."

The still-growing Rhizobium germplasm collection now exceeds 1700 accessions. The lyophilization of this collection is about 40% complete. The lyophilization program is time-consuming and NifTAL researchers lack the time and resources to adequately characterize the collection. Requests from LDC scientists are for relatively few of the strains. The Review Team feels NifTAL could reduce its collection to a smaller number of accessions and concentrate its resources to characterize those strains most likely to be used by LDC researchers.

NifTAL researchers have identified three antigenically distinct rhizobial strains for each of the 16 major tropical legume crops, have prepared antisera against these strains and provide (on request) a mixed inoculant of the three strains. This antisera collection provides a powerful research tool available to LDC scientists. The number of requests for antiserum has been surprisingly low. Of the INLIT cooperators who completed the A trial, few were interested in continuing the rhizobial competition experiments in B trials. A revitalization of the INLIT trials to include the serology of strains within legume nodules will increase the use of this resource.

NifTAL researchers have investigated the influence of soil Al, S, Ca, P, nitrate, salinity, and acidity on the legume symbiosis. These abiotic stress factors limiting fixation have been and are being studied by many research laboratories elsewhere. The Review Team felt that NifTAL could make more of an impact if it concentrated on the study of one limiting factor rather than the entire array. An appropriate goal would be legume-rhizobia combinations which do not have a high phosphate requirement, because many LDC farmers cannot afford the P fertilizer required for good yields of legumes.

Only one of the sub-contractors to NifTAL was visited by the Review Team -- Dr. Donald Munns, University of California, Davis. Dr. Munn's research has emphasized the influence of soil stress factors (soil infertility) on the effectiveness of the legume symbiosis. Current research areas include the salt tolerance of *Sesbania*, the role of plant phospholipids on VA mycorrhizal infection and phytic acid as a P source for rhizobia. The Review Team found the program to be both productive and of high quality. However, the graduate students supported by NifTAL funds have had no contact with NifTAL; and there has been little effort to coordinate Dr. Munn's research program with the research at Maui. It is the feeling of the Review Team that the funds of the current sub-contract might be better used to support the in-house research program of NifTAL at Maui.

Research has begun on measuring N inputs into tropical cropping systems. Experiments have been conducted to determine N fixation by peanut, cowpea and soybean and kidney bean. The effect of intercropping was assessed by measuring N fixation by cowpea and kidney bean intercropped with corn. Because there are no established procedures for measuring N fixation by trees, NifTAL scientists are attempting to develop methods for use with *Sesbania grandiflora*, *Leucaena leucocephala*, *Albizia lebbeck* and *Irga jinicuil*. The panel felt that NifTAL resources were inadequate for a proper study of all these cropping systems. By focusing efforts on measuring fixation by trees, NifTAL could make a contribution to an important topic which is not studied elsewhere.

Research Staff

The number of senior research scientists at Maui is small; and many have additional responsibilities in other components of NifTAL's program. The

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program would be greatly improved if additional staffing could be made available. The Review Team felt that the nature and quality of the research accomplished to date should attract additional scientists as well as other supplemental sources of funding. NifTAL scientists holding appointments at the University of Hawaii are encouraged to apply for competitive grants from USDA or NSF. AID should also change current regulations which would allow other agencies to "buy in" to research during the next contract. This topic is also addressed elsewhere in this report. Visiting scientists from other universities or Federal agencies with their own support could be encouraged to do research at Maui during sabbaticals or study leaves.

NifTAL has not encouraged the participation of graduate students in priority research to the extent that might be possible. Graduate students doing course work on Oahu find it difficult to conduct research at NifTAL. Research project at NifTAL would provide good thesis material for students from the US and from tropical LDC countries. Their participation would require aid and encouragement from the University of Hawaii administration and faculty.

Training and Communication

The stated objective for this task is to disseminate NifTAL research output and transfer professional skills and technical information for research, extension, and production enterprises required to assess and use technologies based on biological nitrogen fixation for crop production in the tropics.

The general feeling of the Review Team is that the NifTAL staff have met the training and communications obligations of the contract in a highly effective manner. This Review Team has been impressed by the variety and quality of the training opportunities provided, e.g. resident internship for BNF technical people and scientists, support of graduate research assistantships, and the variety of short courses designed for a broad range of user audiences. A review of both the 1983 and 1984 Annual Reports documents the variety of topics covered in short courses in many LDC countries and the obvious evolution in the breadth of the course offerings. It seemed obvious to the Review Team that the demand for a variety of short courses will continue to increase especially if/and when NifTAL becomes even better known to the LDC Agricultural Ministries and USAID Missions. These BNF short courses are an essential part of NifTAL's mission and essential to NifTAL function.

The ability to provide appropriate and needed short courses to different user groups are likely to be severely limited by financial and staffing constraints. The need remains high and all efforts to expand this specific short course training must be pursued. This fulfillment of demand can only be achieved by using the financial resources of USAID missions, other international donor groups, and by LDCs themselves or by the development of more cost-effective modes for delivery of information. Staffing constraints can be partially alleviated by utilizing interested BNF scientists from other universities as well as LDC or graduated countries. It is to the credit of the NifTAL Administration that these avenues have already been explored. It will be even more important to utilize this approach in the future.

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NIFTAL training manuals and materials have been developed for courses in BNF technology and inoculant production, and partially developed for courses in BNF for extension workers. As excellent as these materials may be, NIFTAL must remain alert and responsive to the need for tailor-making courses to the technical needs and abilities of a variety of audiences. The team supports NIFTAL's plans to develop a modular approach for training materials. A continuing need exists for a staff person skilled in the development of innovative training materials.

The value of the intern program for LDC technical and scientific staff training in BNF is unquestioned by the Review Team and by the NIFTAL staff. However, the varied times in residence for the internships and the selection process itself seems to place an undue and truly disruptive demand on the NIFTAL staff. The Review Team urges that a strategy be developed to reduce these problems and to more effectively integrate the training into normal operations of NIFTAL. Possible strategies include a more rigorous screening of candidates to assure qualifications, scheduling of interns into specific time periods of the year, a request that the goals of each intern be clearly specified before acceptance, etc. The NIFTAL staff is well aware of these problems and is willing to develop a plan to correct them.

The continued funding of graduate students by NIFTAL seems essential to the viability and professional growth of the program and the research staff. Numerous challenging research areas remain and many will continue to be identified. The best possible candidates both from LDC countries and the U.S. should be identified and admitted.

Various communications documents have been developed and supported by NIFTAL. Perhaps the most important of these is the BNF Bulletin. There is no doubt that this Bulletin provides a valuable vehicle for information and exchange of ideas between and for BNF researchers in LDC and developed countries. The periodic bibliography included with the Bulletin is also a valuable service and a well-conceived idea. Depending on the availability of funding, NIFTAL should consider developing for distribution, literature reviews on topics important to BNF technology, e.g. inoculation carriers, inoculation techniques, Rhizobium ecology, BNF by specific legumes, etc. The availability of scientific information to LDC scientists is generally limited because of inadequate libraries and journal collections. NIFTAL should consider ways to enhance and expand the availability of information to LDC countries. Ideas might include packaging reprints dealing with specific topics for distribution, serving as a broker to identify and distribute library journals from retiring scientists, etc.

The Review Team perceived the need for improved visibility by decision-makers and ADO staff in LDCs and USAID Missions. The NIFTAL publication, Resources and Development is well written; and its distribution may help educate the above groups concerning the expertise and services which can and should be provided by NIFTAL. However, more needs to be done. The Director, and in-country coordinators should enhance NIFTAL's visibility in USAID Washington, D.C., USAID Missions, and with LDC decisionmakers. The program manager in USAID/S&T should also continue to work for enhanced recognition of the NIFTAL program and services.

The NIFTAL staff has attempted to maintain contact with previous interns and INLIT cooperators through the BNF Bulletin and the INLIT Newsletter and can be commended for these efforts. However, the Review Team felt that insufficient attention has been focused in the continuing nurturing and support of these important contacts. Likewise, the evaluation of the impacts of intern training, workshop training, and INLIT cooperation seems to be lacking, or at least loosely assembled. A strategy should be developed (perhaps with a communication expert's involvement to improve communication with interns and INLIT cooperators and to more effectively document the impacts and benefits derived by their participation in these programs.

Outreach Programs in NIFTAL

The INLIT program is, in many ways, the focal point for all of NIFTAL's other efforts including laboratory research, field trials, inoculant production technology, and its training programs. The INLIT field trials are the products upon which NIFTAL's overall effectiveness will be judged. INLIT successes and failures may well be the currency for future cost/benefit analyses by AID and/or future review teams. Despite these observations, the recommendations of an earlier review team, and a large amount of expenditure and effort, the INLIT facet of NIFTAL appears to be the weakest and the area in greatest need of improvement. Full implementation of BNF technology in LDCs will require the subtle use of discretion in cultural, socioeconomic and political areas. These requirements are in addition to the difficulties related to delivery of technology to inoculant users, producers and farmers in LDCs, and the acceptance of this new technology in farming. The two sets of requirements necessary for full implementation of BNF technology are

intricately interwoven; and progress will come only through careful integration of both sets of requirements. The INLIT trials are of paramount importance; and if the project is to be successful in delivery, it must be given the most careful consideration and have the most skillful guidance.

In the past, there seems to have been a somewhat serendipitous approach used in parts of this crucial NIFTAL function. When INLIT responses were returned, positive results were not as adequately quantified and analyzed as would have been desirable.

The Review Team feels that the positive responses should have been vigorously disseminated in a manner to influence local LDC agricultural/political decisionmakers or to local entrepreneurs with an interest in developing local inoculant production centers.

In addition, a lack of response or negative results were not followed up and the reasons for failure explored were not adequately explained and corrected. Finally, the potentially very important INLIT B experiments were never encouraged or emphasized even with the more excellent and responsive of the INLIT LDC cooperators. The Review Team feels that the failure to do serological analysis of nodule occupancy in many geographical and climatic regions of the tropics represents the loss of a research opportunity. The INLIT A trials allow some inference about the response of various legumes to inoculation, but the INLIT B trials allow for an explanation of why successes or failures actually have occurred. They would provide some scientific basis to evaluate the competitiveness, long-term persistence, and effectiveness of

the specifically selected NIFTAL Rhizobium strains over wide geographical, soil, and climatic zones. No other program or network has the opportunity to reach and mobilize the number of BNF scientists in as many locations as the INLIT program.

It can be argued that NIFTAL did not have adequate staff or financial resources to accomplish more with INLIT than that which has been done. The Review Team recognizes these problems, but recommends that the INLIT program be restructured and reemphasized to correct the deficiencies which have been noted. This is much too important a window of opportunity for answering research questions and to positively influence BNF technology adoption in the LDC countries not to make a concerted effort to improve the effectiveness of the program.

Final solutions to an enhanced and improved INLIT program are difficult for the Review Team to recommend. Some prescreening of INLIT collaborators seems absolutely necessary. This could involve encouraging participation by individuals and/or research groups who have at least minimal support from their institution or government ministry. Particularly gifted or talented cooperators can be identified and encouraged through contacts during intern training courses, special training courses, or through in-country consulting contacts. The Team recognizes that this has been done to some degree in the past, but greater effort with a select few may be more effective than a "broad brush" approach.

Consultative Services

Providing consultative services in LDC's is a crucial and important part of the NIFTAL's Outreach Program. This activity has the potential for estab-

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lishing personal and professional relationships essential for sustaining research progress and technology transfer. The major problem perceived by the Review Team is how this effort can be funded without adversely affecting NIFTAL's core budget and how the senior staff can be involved without interfering with the fulfillment of their other essential responsibilities. The recommendation is that consultation should be encouraged but selectively employed. Host country sincerity should be manifest by a willingness to provide at least partial funding.

To some extent, consulting activities overlap and support INLIT training courses, inoculum production centers, and the Research Resource Centers. The NIFTAL Director, when making decisions on consulting should make every effort to determine that it will be complimentary and not duplicative of time, effort, and finances.

Resource Centers

Every LDC country has some degree of BNF expertise and technology, but practically all of them need additional technical support and encouragement. NIFTAL BNF Resource Centers provide an innovative and potentially effective way to provide professional and technical training appropriate to local needs and to allow BNF technology to be adapted for an array of soil, legume, and climatic variables. The established center in Bangkok, Thailand, was visited by the Review Team and appears to be an excellent model. The greatest potential for increasing NIFTAL's effectiveness in reaching its goals would appear to rest in establishing other centers in axillary points within LDC countries where there is concrete evidence of local scientific, philosophical, and financial support.

The center at Bangkok appeared to be an effective program meeting the criteria noted above. The greatest risk and potential problem perceived by the Review Team is that the scientist involved (Dr. Beck) will feel separated and isolated from NifTAL activity and program support. The Director should do everything possible to provide the core financial support necessary, improved communication links, and personal contact necessary to minimize this problem. At the same time, the Bangkok center should be encouraged to seek and obtain local funding and more interaction with USAID Missions in other Asian countries.